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Editorial.

The Relation Between Electric and Magnetic Fields.

IN our Correspondence columns a long letter is published in which Mr. Carl Englund, the well-known American radio engineer, subjects our February editorial on "The Relation Between Electric and Magnetic Fields" to some criticism. We agree almost entirely with Mr. Englund's letter; in fact, the only parts with which we disagree are those in which he criticises our editorial. No one who is familiar with Clerk-Maxwell, whether in the original treatise or in one of the more easily digested forms such as Abraham and Föppl's well-known text-book, will be at all horrified at Mr. Englund's statements. We do not agree, however, that there was anything in the editorial contrary to these statements. We may have followed the usual convention of ascribing the induced E.M.F. in a coil to the changing magnetic field without going through an intermediate explanation of how the varying magnetic flux induces an electric field which acts upon the electrons. Of this we are quite unrepentant. Where, however, did we speak "of alternating fields of one kind without the presence of fields of the other kind"? Mr. Englund gives no precise reference, but we may quote the following passages from the editorial: "It is possible to take any given space and screen it against the electric field of the passing wave so that within the space there will be an alternating magnetic field and *no electric field except that set up by the alternating magnetic field.* Similarly it is possible to screen a space against the magnetic field of the passing wave so that within the space there will be an alternating electric field and *no magnetic field except that set up by the alternating electric field.*" Again, "there are, of course, electric forces inside the cage, but they are *the forces produced by any alternating magnetic flux.*"

Surely there is no room here for misunderstanding; it is clearly stated that, although you may by screening alter the relation existing between the electric and magnetic fields in the wave outside the screen, you cannot have one field without the other inside the screen. In all statements of electromagnetic induction it would probably be more correct to say that the one effect is *associated with* the other rather than *produced by* it, but when Mr. Englund says that the E.M.F. is not produced by the varying magnetic flux linking the circuit we feel inclined to reply that the sculptor does not produce the statue, he merely hits one end of a chisel, the other end of which produces the statue. I feel sure that we both should agree that the sculptor was associated with the statue.

G. W. O. H.

Applications of the Method of Alignment to Reactance Computations and Simple Filter Theory.*

By W. A. Barclay, M.A.

(*Continued from page 65 of February issue.*)

PART II.

§5. Filters.

IN the following sections of this paper an attempt has been made to present a systematic enquiry into the principles of reactive filters. There appears to be considerable need for such an enquiry, as the literature here on the subject seems to be scanty. An article dealing with filter design from the able pen of Mr. P. K. Turner appeared some time ago in this journal (see *E.W. & W.E.*, Aug., 1925); the present exposition is intended to go somewhat deeper into the theory, and will, it is hoped, result in some simplifications to the former paper. In particular, the filters described by Mr. Turner were restricted to a certain type—the T-section, and were further limited by the convention that the extreme end components were made of half the values of the others. This has always appeared to the present writer to be unnecessary and highly artificial. The treatment which follows has the distinction of being perfectly general and applicable to all filter types.

There exists, further, a certain misapprehension as to the precise function of a filter. Many people are accustomed to think of the cutting-off properties of the filter as inherent solely in the filter itself, and hence speak loosely of "high-pass" and "low-pass" filters. To a limited extent this terminology is legitimate, but it should never be forgotten that a filter must always be considered in combination with its working load, and that what might be a "high-pass" filter when used with a certain load might operate in an entirely different manner when used with a load of a different type. Indeed, the only safe plan is to draw out the curve of filtering effect over a range of frequencies. The arithmetical calculations involved in this work would normally be prohibitive; with the simplifications introduced by the use of the Alignment Principle, they become quite possible and even easy. There is great need, however, for a simple means of calculating the constants of a filter which shall cut off a certain given band of frequencies when used with a given load. The writer must admit that so far the general solution of this problem has evaded him. But he has been able to provide the next best thing, *viz.*, a rapid means of estimating the performance of any given filter under given conditions, so that the action of different filters may be readily compared, and from the numerical results that filter selected which approximates most nearly to the desired effect. A problem clearly stated, moreover, is a problem well on the road to solution, and perhaps herein lies the main justification for the present article, while it is confidently believed that the methods here employed may contribute their quota in solving the inverse problems of filter design.

* MS. received by Editor, March, 1929.

§6. Filtering Ratio.

Let us imagine an alternating e.m.f. of constant amplitude e and frequency $\omega/2\pi$ applied to the terminals of a receiver whose impedance W is, of course, a function of that frequency. Then the current flowing in such a receiver will obviously be represented by $i = e/W$, where the symbols have the extended meaning proper to a.c. equations. If now we interpose between the receiver W and the source e a reactive network X in the manner shown in Fig. 7, the current flowing in the receiver will be modified.

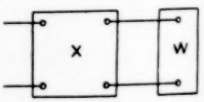

Fig. 7.

Such a reactive network will be termed a "filter stage," and it will be noted that it has two input and two output terminals. It is, of course, possible to connect several such stages in series (or, indeed, by other methods), and the efficacy of the filter at any frequency will be measured by the effect on the resulting current in the receiver or load. A convenient measure of the performance of the filter at any given frequency will thus be the ratio

$$\rho = \frac{i_0}{i'} \quad .. \quad .. \quad .. \quad (1)$$

where i_0 denotes the current passing through the load W when the source e is applied directly to it, and i' that passing through the same load when the filter is inserted between it and the source. This "filtering ratio" ρ is not a fixed constant of the filter, but depends partly on the nature of the load as well as upon the frequency of the applied e.m.f.

We may write, for a given frequency, $i' = \frac{1}{\rho} \times i_0$, and it might be thought, at first sight, that if we now added a second filter stage precisely similar in all respects to the first, the current of that frequency in the load would be further reduced in the same ratio, or

$$i'' = \frac{1}{\rho} \times i' = \frac{1}{\rho^2} \times i_0$$

If this were indeed true the subject of filters would be vastly simplified; unfortunately, in the general case it does not at all follow. The laws of filter combinations are distinctly more complicated than those of ordinary circuits, but there is nothing inherently difficult about them. As an example of the unexpected intricacies of the subject it may be noted that the filtering effect of two separate filters A and B, when placed in series, depends in part upon the order in which they are placed in the circuit; A followed by B giving in general a different effect from B followed by A. To this subject we shall return.

§7. Reactive Networks.

The filters dealt with in the following notes are all reactive in nature, the effect of resistance being throughout neglected. This is done for two reasons. In the actual design of frequency filters, the resistance element is usually very small, and the approximations obtained by neglecting it are generally sufficiently accurate for practical work. Secondly, the general mathematical investigation taking resistance into account is extremely complicated. While it may be observed in passing that by means of the Heaviside Resistance Operators the analytical difficulties may be considerably reduced, the sad fact remains that their numerical interpretation in practice is quite another matter!

The present study is confined, then, to filters consisting of inductances and capacities, either singly or in combination, when interposed as above described between a source of e.m.f.s and a load. This load itself will for the present be considered as reactive, *i.e.*, itself an inductance or capacity or some combination of the two. Later on it is hoped to discuss the effect on filter response of a resistive load.

As is well known, the currents produced when the same alternating e.m.f. is applied across an inductance and a capacity are 180° out of phase with each other, *i.e.*, they may be represented in our analytical "shorthand" as of opposite sign. The fact that each is 90° out of phase with the applied e.m.f. does not here concern us as there is no question of any resistance component. What is important is that throughout our subsequent work all the currents dealt with will be reactive in nature, and may thus be reckoned positive or negative according to some arbitrary convention. The convention that we shall adopt is the usual one that the current due to an e.m.f. acting across an inductance shall be positive, *e.g.*, $+\frac{e}{\omega L}$, while that similarly obtained from a capacity is negative, *e.g.*, $-e \cdot \omega C$. We shall find it convenient, further, to consider the reactances rather than the actual currents flowing through them, and these may also be regarded as positive and negative, according as they are inductive or capacitative in nature. Thus, the reactance of an inductance L and capacity C in parallel is expressed as

$$\frac{\omega L}{1 - \omega^2 LC}$$

its nature for any frequency depending on

the sign of the numerical result obtained by substituting the particular values in the formula.

If we plot graphs showing against frequency the reactance of various simple combinations of inductance and capacity we obtain the curves shown in Fig. 8. The derivation and properties of these curves will be familiar to all readers of this journal, but it should be mentioned in passing how very much their construction is simplified by the use of the Alignment Diagrams given in Part I of this paper.

§8. Law of Positive Increments.

One important feature is possessed in common by all the curves of Fig. 8, viz., that the gradient of each curve taken at every point (except at points of discontinuity) is always positive. In other words, a pure reactance between any two points of a circuit always has a positive increment for a positive increment of frequency. In mathematical notation, if X be the reactance at frequency $\frac{\omega}{2\pi}$, then $\frac{dX}{d\omega}$ is positive. This will now be shown to hold true for the reactance of any network, no matter how complicated, when considered as acting between any two points or terminals upon it.

In the first place, if we differentiate with respect to ω the reactances ωL and $-\frac{1}{\omega C}$ for an inductance and capacity taken singly we have

$$\frac{d}{d\omega} \cdot \omega L = L$$

$$\frac{d}{d\omega}\left(-\frac{1}{\omega C}\right) = \frac{1}{\omega^2 C}$$

so that the differential coefficients of the ultimate constituents of a reactive network are always positive. Next, let A and B be two reactances such that their differential coefficients $\frac{dA}{d\omega}$ and $\frac{dB}{d\omega}$ are both positive. Then the differential coefficients of the reactance of the two in series will be

$$\frac{dA}{d\omega} + \frac{dB}{d\omega},$$

a positive quantity. Again, if A be placed in parallel with B, then if Z be the reactance of the combination, $Z = \frac{AB}{A+B}$.

Hence,

$$\frac{dZ}{d\omega} = \frac{(A+B)\left\{B \cdot \frac{dA}{d\omega} + A \cdot \frac{dB}{d\omega}\right\} - AB\left\{\frac{dA}{d\omega} + \frac{dB}{d\omega}\right\}}{(A+B)^2}$$

$$= \frac{A^2 \cdot \frac{dB}{d\omega} + B^2 \cdot \frac{dA}{d\omega}}{(A+B)^2}$$

which is seen to be positive, irrespective of the signs of A and B. Thus any series and parallel combinations of A and B, and hence all reactive networks composed of

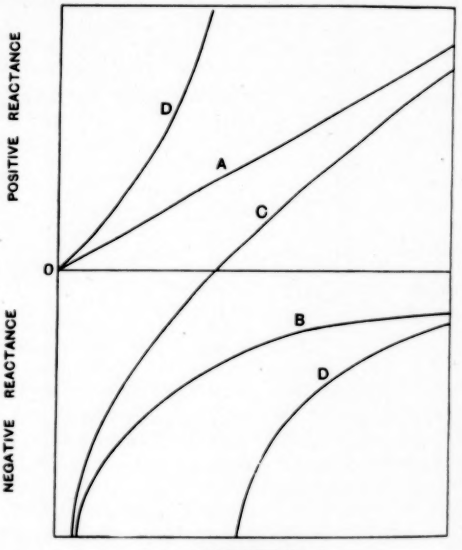

Fig. 8.—*Typical curves showing variation of reactance with frequency. A = Inductance, B = Capacity, C = Inductance and Capacity in series, D = Inductance and Capacity in parallel.*

inductances and capacities when considered as between any two points of the circuit containing them, have this property of a positive gradient of their frequency-reactance curve, the axes being taken, of course, as in Fig. 8.

§9. Filter Input Reactance.

Attention has been directed to the fact that a filter has, properly speaking, four

terminals, two input and two output. For this reason we cannot strictly speak of the reactance of a filter, as this term connotes a reactance between *two* points of a circuit. Nevertheless, we can consider the reactance which is offered to the input e.m.f. by the whole combination of filter and load across the input terminals. This we shall call the "input reactance" of the filter for the given load and frequency, on which two quantities it obviously depends. Being a pure reactance considered between the two input terminals of the filter, it will follow the law of positive gradients. We shall allot to it the symbol X, and if we take i as the input current flowing into the filter we may write $i = \frac{e}{X}$. In the sequel we shall endeavour to show how the value of X may be rapidly obtained for different types of filter, load and frequency.

§10. Filter Reactance.

A more important matter than the determination of input current is that of output current since it is with the object of regulating this that the filter has its *raison d'être*. We have seen that the effect of interposing the filter is to alter the load current from i_0 to i' for the same impressed e.m.f. The ratio e/i' will therefore be of importance as showing directly the dependence of the output current on the input voltage. To this ratio may be assigned the name "filter reactance," and to it we shall allot the symbol F. It is important to note that, unlike the "input reactance," the "filter reactance" is not a reactance in the true sense of the term. That is to say, while it has the dimensions of a reactance, it is not defined as the reactance between two given points in a circuit. For this reason it will be found that it does not follow the law of positive gradients, and will often attain maximum or minimum values for a particular frequency. Like X, the filter reactance is not entirely a property of the filter, but depends also upon the load W. To obtain rapidly numerical values of F as frequency is varied is also a main object of this paper.

§11. Filter Characteristics.

So far we are still without any direct means of specifying a filter considered without reference to a load otherwise than by enumerating the constituents of which it is actually composed. Now it is possible to discover certain "standard characteristics" of a filter which may be used to specify it at any frequency. The characteristics of one filter stage will be found to possess the quality of combining with those of another stage to form a set of fresh characteristics of the two stages in combination—all without reference to a possible load. In order to obtain these characteristics we shall assume a constant frequency of input e.m.f., and consider the amplitudes of voltage across the input and output terminals of the filter, as well as the input and output currents—those taken from the source and through the load. (See Fig. 9).

Now, no matter what be the actual constitution of the filter network, assuming it to be connected up to load W, it will always be found that an increase in the input voltage e across the filter will result in a proportional increase in the output voltage e' across W. For any particular load (the frequency being supposed constant throughout), we may thus write

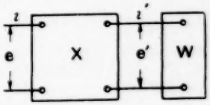

Fig. 9.

$$e = he'$$

where h is a constant depending partly upon the load. (Note that there is no constant term since the equation is true for zero values.) Again, an increase of e will also result in a proportional increase of output current i', so that we have also,

$$e = ki'$$

where k is also a function of the load. If now we assume that

$$e = Ae' + Bi' \quad .. \quad .. \quad (2)$$

where A and B are constants *solely depending on the filter*, we have, since $i' = e'/W$

$$e = \left(A + \frac{B}{W}\right) . e' \text{ and } e = (AW + B) . i' \quad (3)$$

where the bracket values are constants corresponding to h and k above. The assumption of equation (2) is thus legitimate. In order to determine the filter constants A and B, which are independent of the load,

we shall note the values of e' and i' in equations (2) when W is made infinite and zero respectively. If W is infinite this is equivalent to open-circuiting the filter at the load end. When this is the case $i' = O$, and writing e'_∞ for the value of e' under these conditions, we have from (2)

$$A = \frac{e}{e'_\infty} \quad .. \quad .. \quad (4)$$

Again, if the load reactance W is zero, *i.e.*, the output terminals of the filter are short-circuited, we have $e' = O$, and writing i'_0 for the current flowing in the shorting wire,

$$B = \frac{e}{i'_0} \quad .. \quad .. \quad (5)$$

The quantities A and B having thus been found may be used in equation (2), which thus shows the relation between e, e' and i' for any load at the particular frequency.

By a similar procedure relating to the input current i of the filter we can obtain an analogous equation

$$i = Ce' + Di' \quad .. \quad .. \quad (6)$$

where C and D are also characteristics solely of the filter at the frequency dealt with. Using suffixes to denote the nature of the load, the values of C and D are found to be

$$C = \frac{i_\infty}{e'_\infty} \quad .. \quad .. \quad (7)$$

$$D = \frac{i_0}{i'_0} \quad .. \quad .. \quad (8)$$

We can now express the filter reactance F and input reactance X in terms of our fundamental filter characteristics. We shall have for the former

$$F = \frac{e}{i'} = \frac{Ae' + Bi'}{i'} = A \cdot \frac{e'}{i'} + B$$

But the ratio e'/i' is, of course, the load reactance W. Hence we write

$$F = AW + B \quad .. \quad .. \quad (9)$$

Again for the input reactance

$$X = \frac{e}{i} = \frac{Ae' + Bi'}{Ce' + Di'} = \frac{AW + B}{CW + D} \quad .. \quad (10)$$

Any reactive filter, whatever its actual composition, is thus completely specified as to its action at any given frequency when the four characteristics A, B, C, D appropriate to it are known.

§12. Utility of Filter Characteristics.

It is important to remark that, since the above analysis assumed a constant frequency, these characteristics A, B, C, D are functions of the frequency which is being used, and are not true constants of the filter itself. Hence it is that although two different filters may be found to have the same numerical values for their characteristics at one particular frequency, it will not follow that their performance will be identical over a range of frequencies. The only criterion of similarity of performance between two filters lies in the identity of their frequency *functions* A, B, C, D.

It will be evident that the frequency characteristics are not intrinsically important; their chief service is to afford a convenient means of expressing the functions F and X with which we are primarily concerned. It must not be thought, however, that it will be necessary to compute values of A, B, C, D for all frequencies before the corresponding values of F and X are ascertained. On the contrary, means will be found later to compute values of F and X graphically, direct from the reactance values of the filter components themselves. Meanwhile we shall continue to make use of the functions A, B, C, D, as they are indispensable to the complete presentation of the subject and are moreover especially useful in the study of compound filters of two or more stages.

§13. Dimensions of Filter Characteristics.

Before going on to examine various standard filters, we may consider the dimensions of the filter characteristics obtained above. (See "The Dimensionality of Wireless Equations," *E.W. & W.E.*, April, 1928). The left side of (2) is an e.m.f. In order that the terms of its R.H. side correspond, A must be a pure number, while B will have the dimensions of an impedance, or for the purposes of this paper where reactive values are alone considered, of a reactance. Again, in order that all the terms of equation (6) shall be of the dimensions of a current, C must have the dimensions of a susceptance, the reciprocal of a reactance, while D is a pure number. These dimensions are found

on substitution in equations (9) and (10) to tally with the reactive dimensions of F and X.

§14. Single-stage T-filter.

We shall now derive expressions for the four characteristics A, B, C, D for some standard types of filter at a given frequency. Figs 10a and 10b illustrate a single stage of the most general T-type of filter, whose output terminals are respectively open and short-circuited. The symbols P, Q, R repre-

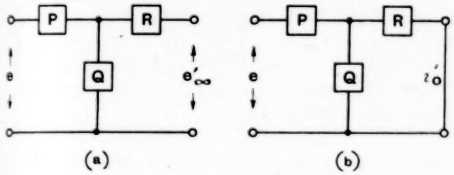

Fig. 10.—(a) *T-filter—on open circuit.* (b) *The same—short-circuited.*

sent the numerical values of the reactances concerned at the given frequency, and may be due to various combinations of inductance and capacity. These values may readily be obtained from the Alignment Charts given in Part I of this paper. From simple circuit theory we can obtain the voltages and currents in every portion of these networks for a given impressed e.m.f. e. If i_0 and i'_0 denote input and output current for zero load, and i_∞ and e'_∞ denote input current and output voltage for infinite load (or open-circuit), it can be readily shown that

$$\left.\begin{aligned} i_\infty &= \frac{e}{P+Q} & i_0 &= \frac{e\,.\,(Q+R)}{PQ+PR+QR} \\ e'_\infty &= \frac{e\,.\,Q}{P+Q} & i'_0 &= \frac{e\,.\,Q}{PQ+PR+QR} \end{aligned}\right\} \quad (11)$$

Hence, in accordance with equations (4), (5), (7), and (8), for this type of filter,

$$\left.\begin{aligned} A &= 1+\frac{P}{Q} \\ B &= P+R\left(1+\frac{P}{Q}\right) \\ C &= \frac{1}{Q} \\ D &= 1+\frac{R}{Q} \end{aligned}\right\} \quad .. \quad (12)$$

The filter reactance of one such T-stage when used with a load of reactance W will thus be, from equation (9),

$$\begin{aligned} F &= \left(1+\frac{P}{Q}\right).W+P+R\left(1+\frac{P}{Q}\right) \\ &= P+\left(1+\frac{P}{Q}\right)(R+W) \quad .. \quad (13) \end{aligned}$$

while its input reactance is, from equation (10),

$$X = \frac{PQ+(P+Q)(R+W)}{W+Q+R} \quad .. \quad (14)$$

In these equations all the symbols employed have reference to the particular frequency under discussion; in other words, they are all functions of frequency, and vary with it.

§15. Single-stage π-filter.

Another important type of filter is that known as the π-filter, a single stage of which is shown in Fig. 11. If the reactances of the several components as shown be denoted by S, T and U (for the given frequency), it can be similarly established that for this filter,

$$\left.\begin{aligned} A &= 1+\frac{U}{T} \\ B &= U \\ C &= \frac{1}{S}+\frac{1}{T}+\frac{U}{ST} \\ D &= 1+\frac{U}{S} \end{aligned}\right\} \quad .. \quad (15)$$

The filter reactance is here

$$F = \left(1+\frac{U}{T}\right).W+U \quad .. \quad (16)$$

and the input reactance

$$X = \frac{\left(1+\frac{U}{T}\right).W+U}{\left(\frac{1}{S}+\frac{1}{T}+\frac{U}{ST}\right).W+\left(1+\frac{U}{S}\right)} \quad (17)$$

It will be noted that F is independent of the value of S, since this quantity enters into neither of the characteristics A and B for a single stage. This means that the presence or absence of S in a single stage will not affect its filtering qualities, although it naturally has an effect

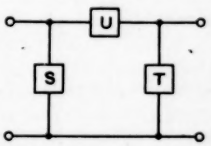

Fig. 11.—*π-filter.*

on current strength. S is really a shunt across the source, and its effect is to diminish the input current. The input reactance, X, of course, depends on S as well as on T and U.

§16. An Important Relation.

We may here notice an important relation between the frequency characteristics A, B, C, D of a filter. These functions are not independent of each other, but are connected by the equation

$$AD - BC = 1 \quad .. \quad .. \quad .. \quad (18)$$

which is true over all frequencies. By direct multiplication of equations (12) this relation may be shown to hold true for single-stage filters of T-type, and by multiplication of equations (15) for single-stage filters of π-type. Later it will be proved to hold for any type of filter, simple or compound.

§17. Equivalence of Filters.

It has been seen that the performance of any two filters will be identical if their frequency characteristics are the same. As an example we may note the cases shown in

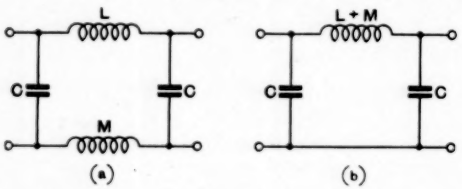

Fig. 12.

Figs. 12a and 12b. It is easy to establish by reasoning similar to that given above that the characteristics of both these filters are identical, and that in practice, therefore, one may be substituted for the other with no alteration to efficiency. The writer is aware that this theoretical result has been called in question in the light of practical experience. It is thought, however, that the last word has not yet been said on the matter, which is one of some importance in filter design. It must, of course, always be borne in mind that actual apparatus will contain an element of resistance which must to some extent invalidate the conclusions drawn for an ideally reactive filter. Nevertheless, the point is one which is worth investigation from an experimental standpoint.

It is in general impossible to substitute a π-type of filter for a T-type, and vice versa. The reasons for this statement and a general

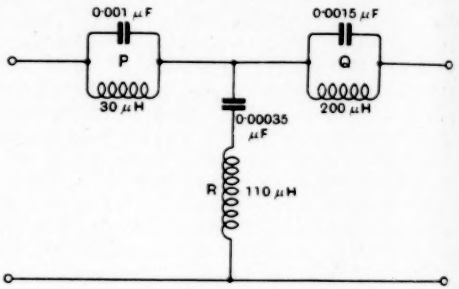

Fig. 13.

discussion of filter equivalence are meantime reserved for future treatment.

§18. Symmetrical Filters.

If in the T-stage filter of Fig. 10 the components which give rise to the reactances P and R are the same, we shall have $P = R$, and the filter may be called "symmetrical." Again, if in the π-stage of Fig. 11 we have $S = T$, the term "symmetrical" may also be applied to it. It may be asked if it is possible to find component values for a symmetrical filter which may take the place of a given unsymmetrical filter. This, again, involves looking at our subject from an inverse point of view, and must meantime be postponed.

§19.—Filter Performance.

So far we have derived expressions for the frequency characteristics of single-stage filters. In practice what is sought is the response over a range of frequencies, and thus our objective will be the numerical evaluation of the functions F and X over the particular frequency band in which we are interested. The treatment which immediately follows is that for a single-stage T-filter; the analogous procedure for a single-stage π-filter being left to the reader.

It will be assumed that graphs have been prepared showing the variations with frequency of the reactances P, Q and R of the filter, and also the load reactance W. Such

graphs are readily prepared by means of the Alignment Charts given in Part I of this paper, where a straight-edge laid across the inductance and capacity values enables the varying reactances to be read off with the frequencies. As an example, we may take the single-stage filter shown in Fig. 13, in which the several components have the values there specified, and estimate its performance over the range of wavelengths 200–500 metres when used in conjunction with a load consisting of a condenser of .0003 μF. capacity. This example is by no means the most suitable that might have been chosen, the values being selected arbitrarily, while wavelengths were preferred to kilocycles to emphasise the generality. Then the response of the component reactances P, Q and R for this filter are shown in Fig. 14, which is readily obtained from the Charts referred to. The variation of the reactance W with frequency is also set out on Fig. 14. This diagram need not take more than five minutes to set out, no calculation at all being necessary.

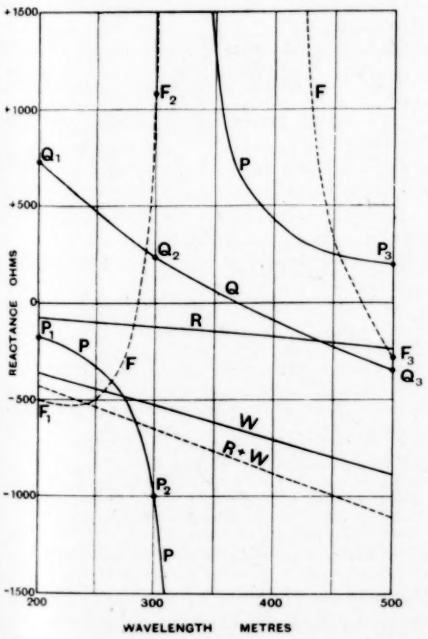

Fig. 14.—*Reactance—frequency graphs of filter—components of Fig. 13. The graph of the filter reactance is also shown.*

We could now, if we please, compute the values of F and X directly for a series

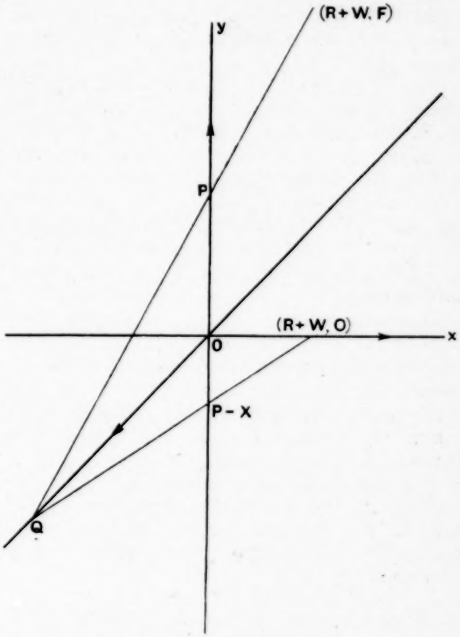

Fig. 15.—*Showing graphical derivation of F and X.*

of selected frequency values by substitution in equations (13) and (14). The arithmetical work involved, however, is such as to render this course altogether impracticable. Fortunately, means are at hand to obtain the values of F and X quite as simply as those of P, Q and R. By an application of the Alignment Principle the filter response curves may be sketched in practically at sight. This will now be described.

§20.—Graphical Estimation of Filter Response.

In Fig. 15, let OX, OY represent ordinary cartesian axes graduated at suitable intervals to represent units of reactance. Then the arrows shown on these axes indicate the directions of increasing magnitude. The paper being reticulated with horizontal and vertical lines to represent reactance values,

we now draw the line $y = x$, as shown, which we shall regard as an independent subsidiary axis, *the positive direction for which, moreover, lies in the third quadrant* (as indicated by the arrow head). The graduation shown at any point on this new axis will thus be minus the x-co-ordinate at this point.

On the vertical axis we now mark a point corresponding to the numerical value of P, above or below the origin as P is positive or negative. Next on the sloping axis we find in the manner detailed above a point corresponding to the value of Q. Join these two points by a straight line, and on it find the point whose abscissa has the value $R + W$. Then the ordinate of this point will measure the value of the quantity F.

The values of $R + W$ are easily obtained from Fig. 14 by summing the ordinates of the separate curves for R and W. This is shown by the broken line. We can now read off conveniently the simultaneous values of P, Q and $R + W$ as the frequency varies. The derivation of the values of F for the case under illustration has been shown in Fig. 16, which contains three lines, those namely for the wavelengths 200, 300 and 500 metres, drawn from the following table of values.

λ metres	P	Q	R	W	$R+W$	F
200	−170	+735	−75	−355	−430	−500
300	−1000	+240	−120	−530	−650	+1060
500	+200	−345	−230	−885	−1115	−280

These three lines give the values of F as shown above, but it should be remembered that the lines do not actually need to be drawn. It is usually sufficient to mark their positions temporarily with a ruler until the values of F are ascertained. The positions of the F points may be thus quickly set out, and their locus is indicated in Fig. 16 by the broken curve which was obtained by this process. It is then a simple matter to transfer the values of F back to the frequency diagram, Fig. 14, on which the F curve is also shown by a broken line. It may be pointed out that, save for the special treatment accorded to the Q-points, the diagram of Fig. 16 is entirely cartesian, *i.e.*, the values set out on it conform in position to their algebraic sign.

The diagrams Figs. 15 and 16 may be further utilised to find the values of X, the input reactance. If the point Q as found on the sloping axis be joined to a point on the horizontal axis of value $R + W$, this line will meet the vertical axis in a point whose ordinate will be $P - X$. But a point whose ordinate is P has already been found on this vertical axis. The distance between these two points on the vertical axis, taken with appropriate sign, thus gives a measure of X. If the point P lie above the point $P - X$, X will be positive, while if P lie below $P - X$, X will be negative (see Fig. 15).

Detailed proofs of these constructions

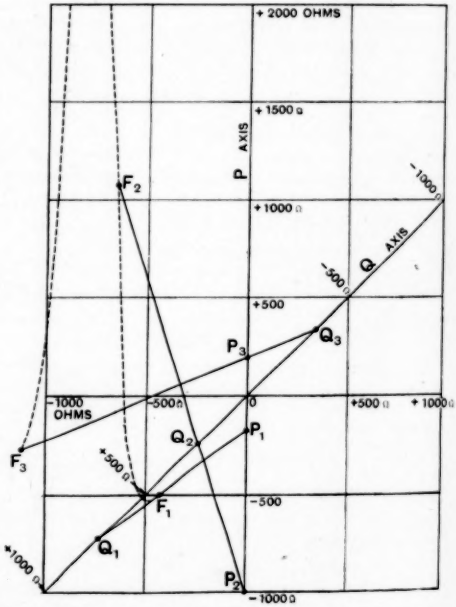

Fig. 16.—*Showing derivation of values of F for filter of Fig. 13. The three constructional lines, P_1 Q_1 F_1, P_2 Q_2 F_2 and P_3 Q_3 F_3 do not actually require to be drawn in practice.*

need not be given here. It may, however, suffice to remark that the condition that the three points $(0, P)$, $(-Q, -Q)$ and $(R + W, F)$ should be in alignment is precisely equation (13), while the condition

that the points $(O, P - X)$, $(-Q, -Q)$, and $(R + W, O)$ should be in alignment is precisely equation (14).

It will be evident that the above procedure affords a quick means of estimating the response of a given filter over a given frequency range. For our example, the wavelengths at which "cut-off" takes place are read off from Fig. 14 as 300 m. and 430 m. Between these values all signals will be rejected, and the filter is accordingly a "band-stop." But it is all-important to remember that the nature of the load contributes in a measure to this result.

In the next part of the paper it is hoped to show how the performance of a compound filter of several similar stages may be rapidly derived from that of a single stage.

(To be continued.)

Books Received.

ELECTRICAL WIRING AND CONTRACTING. Vol. II. Edited by H. Marryat, M.I.E.E., M.I.Mech.E.

Comprising D.C. Generators and Motors, Mathematics (as applied to wiring and contracting), A.C. Generators and Motors, Measuring Instruments and Testing, Wires and Cables. Pp. 512, with numerous illustrations and diagrams. Published by Sir Isaac Pitman & Sons, Ltd., London. Price, 6s. net.

THE WIRELESS MANUAL (2nd Edition). By Capt. Jack Frost.

A practical book for the ordinary broadcast listener, giving useful instruction in the erection of aerials, the installation of receiving sets and descriptions of the nature and use of various receivers, valves and components, supplied by wireless manufacturers. Pp. 164+VIII, with 83 illustrations and diagrams. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 5s. net.

THE PRACTICAL ELECTRICIAN'S POCKET BOOK, 1930. Edited by F. H. Robinson.

A comprehensive reference book on all matters of interest to the practical electrician, including Electrical and Magnetic Units, Resistances of Metals and Alloys, Generators, Motors, Wiring, Lighting, Heating, Wireless, Electric Traction, Kinema Equipment, Central Station Working, Electricity Undertakings, etc., etc. The information contained in the 1929 (31st) edition has been revised, and extra sections on Synchronous and Asynchronous Motors, Testing and Fault Localisation, Medical Electricity, and Simple Law of Contracts, have been added.

Pp. 544+lxxvi, with numerous illustrations and diagrams. Published by Electrical Trading and Electricity, London, price 2s. 6d. net.

WAS MUSS DER SPRECHMASCHINENHÄNDLER VON DER ELEKTRISCHEN SCHALLPLATTENWIEDERGABE UN VOM RADIO WIESSEN? By Oscar Gadamer.

A handbook, primarily intended for the use of gramophone dealers, describing the principles, use and maintenance of wireless apparatus in connection with broadcast receivers, gramophone pick-ups, valves, etc. Pp. 80 with 101 illustrations and diagrams. Published by Rothgieser und Diesing, A.G., Berlin. Price M. 1.70.

ELECTRICAL WIRING AND CONTRACTING. Vol. III. Edited by H. Marryat, M.I.E.E., M.I.Mech.E.

Comprising Practical Wiring Work, Switching and Primary and Secondary Cells. Pp. 784, with numerous illustrations. Published by Sir Isaac Pitman & Sons, Ltd., London. Price 6s. net.

REMINDERS FOR COMPANY SECRETARIES (Fifteenth Edition). By H. W. Jordan.

Revised and re-written for the assistance of Secretaries of Limited Companies in view of the additional obligations imposed by the Companies Act, 1929, which came into operation on November 1st. Pp. 66+XXXII. Published by Jordan & Sons, Ltd., London. Price 2s. 6d.

TELEVISION, PRESENT METHODS OF PICTURE TRANSMISSION. By H. Horton Sheldon and E. Norman Grisewood.

The Theory and Practice of Modern Television, with description of the principal systems at present in process of development in Europe and America. Pp. 194 with 129 illustrations and diagrams. Published by the Library Press, Ltd., London. Price, 10s. 6d. net.

PRINCIPLES OF RADIO. By Keith Henney.

A text-book for students, comprising the fundamental laws of Electricity, Inductance, Capacity, Properties of A.C. Circuits, Coils and Condensers, Valves, Amplifiers, Receiving and Transmitting Apparatus, Testing, etc. Pp. 477 + xii, with 306 illustrations and diagrams. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, Ltd., London. Price, 17s. 6d. net.

DIE PHYSIKALISCHEN GRUNDLAGEN DER RUNDFUNK-ANLAGEN. By Manfred von Ardenne.

An up-to-date theoretical introduction to wireless, specially written for the student of Physics or the Radio Experimenter. The book is largely concerned with the valve and associated circuits; multiple valves and screen-grid valves are specially dealt with, and various methods of valve couplings described. Pp. 116 with 84 illustrations and diagrams. Published by Rothgieser und Diesing A.G., Berlin. Price, M. 3.50.

Electrical Wave Filters.

By M. Reed, M.Sc., A.C.G.I., D.I.C.

(*Continued from page 128 of March issue.*)

Section B.

Derived Types of Structures.

An extremely simple method of obtaining the formulæ for the propagation constant and the characteristic impedance of many complex types of symmetrical wave filters is by considering such structures to be derived from simpler types.*

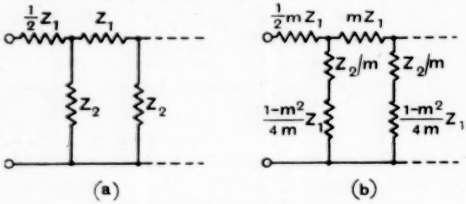

Fig. 15.

Consider two periodic structures of the types shown in Figs. 15(a) and 15(b), in which the structure of Fig. 15(b) is regarded as being derived from the simpler structure of Fig. 15(a).

From equation (1) the mid-series characteristic impedance of the structure shown in Fig. 15(a) is

$$Z_K = \sqrt{Z_1 Z_2 (1 + \tfrac{1}{4} Z_1/Z_2)}.$$

Similarly, the mid-series characteristic impedance of the structure shown in Fig. 15(b) is :—

$$Z_K = \sqrt{mZ_1\left(\frac{Z_2}{m} + \frac{1-m^2}{4m} Z_1\right)\left[1 + \frac{mZ_1}{4\left(\frac{Z_2}{m} + \frac{1-m^2}{4m} Z_1\right)}\right]}$$

$$= \sqrt{Z_1 Z_2 \left(1 + \frac{Z_1}{4Z_2}\right)}$$

which is the same as that for the simpler structure. Therefore, the mid-series characteristic impedances of the two structures are identical.

From (7) it is seen that the propagation constant of any symmetrical structure is dependent only upon the value of Z_1/Z_2.

For the structure of Fig. 15(b), this ratio is given by :—

$$(Z_1/Z_2)_m = \frac{mZ_1}{\frac{Z_2}{m} + \frac{1-m^2}{4m} Z_1}$$

$$= \frac{4m^2 (Z_1/Z_2)}{(1-m^2) Z_1/Z_2 + 4} \quad .. \quad (10)$$

From (10) the following can be seen :—

(*a*) When Z_1/Z_2 of structure 15(a) is zero, then the corresponding ratio $[Z_1/Z_2]_m$ is also zero.

(*b*) Similarly, when $Z_1/Z_2 = -4$, the value of $[Z_1/Z_2]_m$ is also equal to -4.

Therefore the structure of Fig. 15(b) will have the same cut-off frequencies as the simpler structure from which it is derived.

It will be seen, however, from (10), that $[Z_1/Z_2]_m$ can have any value between zero and infinity depending on the value assigned to m. For example, the derived structure

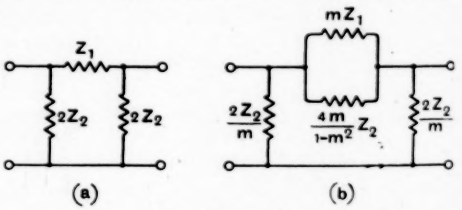

Fig. 16.

will have infinite attenuation when the denominator of (10) is zero,
i.e., when :—

$$Z_1/Z_2 = \frac{-4}{1-m^2}$$

or when $$m = \sqrt{1 + 4Z_2/Z_1} \quad .. \quad (10a)$$

From the above relations it is therefore seen that we can derive from a simpler structure a structure which will have the same mid-series characteristic impedance,

* See Reference 2.

the same cut-off frequencies, but which will, in general, have a different propagation constant depending on the value assigned to m.

In addition to the mid-series derived structure there is also the mid-shunt derived structure. The simple and derived structures of this type are shown in Figs. 16(a) and 16(b), respectively.

By exactly the same method as that employed in the mid-series case, it can be shown that the mid-shunt characteristic impedance of the above structures is the same and is given by equation (8). In

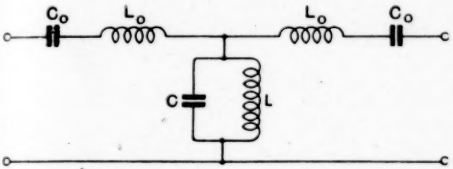

Fig. 17.

addition the ratio of the series to the shunt impedances in the case of Fig. 16(b) is, as in the case of Fig. 15(b),

$$(Z_1/Z_2)_m = \frac{4m^2\, Z_1/Z_2}{(1 - m^2)\, Z_1/Z_2 + 4}$$

It is thus seen that we have two derived structures whose propagation constants are identical and whose characteristic impedances are respectively equal to the mid-series and mid-shunt characteristic impedances of the simpler structures from which they are derived.

It follows from the above that if we have any complex structure, it can be reduced to a simple structure by applying the relationships between the series and shunt arms, as indicated by Figs. 15(a) and 15(b) (for a T network) or Figs. 16(a) and 16(b) (for a Π network). It is then only necessary to obtain direct formulæ for the simple structure in order to determine the properties of the complex structure.

It will be shown in the next section how the use of the "Derived Filter" simplifies the analysis of a complicated filter, and also how it enables us to design filters which shall have attenuation characteristics of a form which are very useful in practice.

An example will illustrate how a complex filter can be obtained from a simple filter. Figs. 17 and 18 show, respectively, a simple band pass filter and its corresponding attenuation-frequency characteristic.

It will be seen from Fig. 18 that the filter of Fig. 17 only has infinite attenuation when the frequency is zero or infinity.

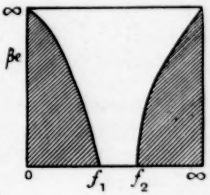

Fig. 18.

Figs. 19 and 20 show, respectively, the derived filter and its attenuation-frequency characteristic.

From Fig. 20 it is seen that the derived filter has the same cut-off frequencies f_1 and f_2, but its attenuation characteristic is different from that of the simpler filter of Fig. 18, the shape of this characteristic being determined by the value assigned to m.

The values of the components of the structure shown in Fig. 19 are obtained from the following relations:—

$$L_1 = mL_0 \quad .. \quad .. \quad .. \quad (a)$$

$$C_1 = C_0/m \quad .. \quad .. \quad .. \quad (b)$$

$$L_2 = \frac{1 - m^2}{4m} \cdot L_0 \quad .. \quad .. \quad (c)$$

$$C_2 = \frac{4m}{1 - m^2} \cdot C_0 \quad .. \quad .. \quad (d)$$

$$L_3 = L_0/m \quad .. \quad .. \quad .. \quad (e)$$

$$C_3 = mC \quad .. \quad .. \quad .. \quad (f)$$

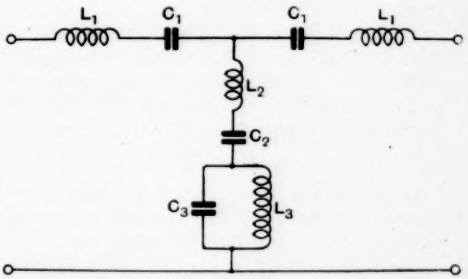

Fig. 19.

From (a) and (b) we have

$$\omega L_1 - \frac{1}{\omega C_1} = m\left(\omega L_0 - \frac{1}{\omega C_0}\right) = mZ_1$$

From (*c*) and (*d*) we have

$$\omega L_2 - \frac{1}{\omega C_2} = \frac{1-m^2}{4m}\left(\omega L_0 - \frac{1}{\omega C_0}\right) = \frac{1-m^2}{4m} Z_1$$

From (*e*) and (*f*) we have

$$\frac{1}{\omega L_3} - \omega C_3 = m\left[\frac{1}{\omega L} - \omega C\right] = m/Z_2$$

Thus indicating that the equations (*a*) to (*f*) satisfy the requirements that the structure of Fig. 19 should be derived from the structure of Fig. 17.

From the foregoing it can be seen that by assigning different values to the parameter "*m*," a number of structures can be obtained which will have the same characteristic impedance and the same cut-off frequencies, but whose attenuation and phase constant characteristics will be different. In the section on Composite Filters, it will be shown how this property enables us to connect any required number of these structures in series, to obtain a filter which satisfies the requirements imposed by practical considerations.

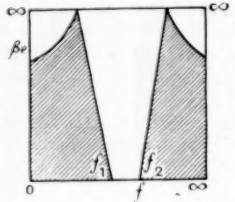

Fig. 20.

The following sections will show how the use of the "Derived Filter" simplifies the analysis of filters in general.

Section C.

Design of Wave Filters.

To show how the general formulæ obtained above can be applied to specific structures, the methods already developed will be used to obtain all the necessary formulæ for a low pass and a band pass filter.

(*i*) *Low Pass Filter.*

Consider the filter shown in Fig. 21. It can be seen that this filter is derived from the simpler structure shown in Fig. 22.

Consideration of Figs. 15(a) and 15(b) will show that the following relations exist between the elements of Figs. 21 and 22.

$$L_1 = mL_0 \quad .. \quad .. \quad .. \quad .. \quad (11)$$

$$L_2 = \frac{1-m^2}{4m} \cdot L_0 \quad .. \quad .. \quad .. \quad (12)$$

$$C_2 = mC_0 \quad .. \quad .. \quad .. \quad (13)$$

Therefore

$$m = L_1/L_0 \text{ and } C_0 = C_2 \times L_0/L_1 \quad (14)$$

From (11) and (12)

$$L_2 = \frac{1-(L_1/L_0)^2}{4L_1^2/L_0^2} = \frac{L_0^2 - L_1^2}{4L_1}$$

$$\therefore \quad L_0^2 = L_1(L_1 + 4L_2) \quad .. \quad .. \quad (15)$$

All the formulæ that we require for the filter of Fig. 21 can be obtained by considering the simpler filter of Fig. 22.

(*a*) *Cut-off Frequency.*

The impedance of the series arm is :—

$$Z_1 = j\omega L_0$$

and that of the shunt arm is :—

$$Z_2 = 1/j\omega C_0$$

where $\omega = 2\pi \times$ frequency $= 2\pi f$

$$\therefore \quad Z_1/Z_2 = -\omega^2 L_0 C_0 \quad .. \quad .. \quad (16)$$

The limiting frequencies which the filter will transmit have been shown to be determined by putting :—

$$Z_1/Z_2 = 0 \text{ and } Z_1/Z_2 = -4.$$

Therefore the filter of Fig. 22 will transmit all frequencies lying between the limits given by

$$-\omega^2 L_0 C_0 = 0 \text{ or } \omega = 0$$

and $-\omega_c^2 L_0 C_0 = -4$ or $\omega_c = 2\pi f_c = \dfrac{2}{\sqrt{L_0 C_0}}$

Therefore the filter of Fig. 22 is a low pass filter transmitting currents of all frequencies lying between zero and the cut-off frequency f_c, where

$$f_c = 1/\pi\sqrt{L_0 C_0} \quad .. \quad .. \quad (17)$$

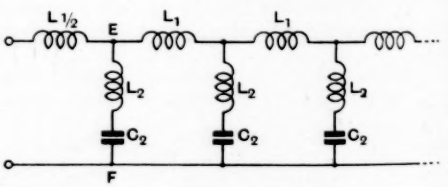

Fig. 21.

From (16) and (17) we have that

$$Z_1/Z_2 = -4(f/f_c)^2 \quad .. \quad .. \quad (18)$$

(*b*) *Mid-Series Characteristic Impedance.*

The mid-series characteristic impedance of any structure is given by formulæ (1).

That is :—

$$Z_K = \sqrt{Z_1 Z_2 (1 + Z_1/4Z_2)}$$

Hence for the structure shown in Fig. 22, the impedance as measured between A and B, when the far end is closed through the mid-series characteristic impedance, is given by :—

$$Z_{AB} = \sqrt{\frac{j\omega L_0}{j\omega C_0}\left(1 - \frac{\omega^2 L_0 C_0}{4}\right)}$$

$$= \sqrt{\frac{L_0}{C_0}}\sqrt{1 - \frac{\omega^2 L_0 C_0}{4}}$$

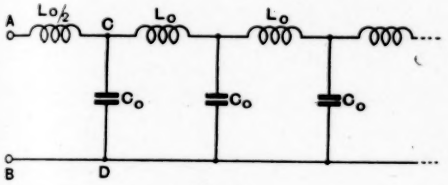

Fig. 22.

From equation (17) we have that

$$4/L_0 C_0 = (2\pi f_c)^2 = \omega_c^2$$

$$\therefore \quad Z_{AB} = \sqrt{\frac{L_0}{C_0}}\sqrt{1 - \left(\frac{\omega}{\omega_c}\right)^2}$$

$$= \sqrt{\frac{L_0}{C_0}}\sqrt{1 - \left(\frac{f}{f_c}\right)^2} \quad .. \quad (19)$$

Since $Z_1 = j\omega L_0$ and $Z_2 = 1/j\omega C_0$

therefore $Z_1 Z_2 = L_0/C_0 = K^2$

It is thus seen that $Z_1 Z_2$ is independent of the frequency. Such a structure is called a "constant — K structure." If Z_0 is defined as the nominal characteristic impedance of a constant — K structure, i.e., the characteristic impedance at the frequency at which $Z_1/Z_2 = 0$, which in this case is at zero frequency, it follows from equation (19) that :—

$$Z_0 = \sqrt{L_0/C_0} \quad .. \qquad .. \quad (19a)$$

therefore $Z_{AB} = Z_0\sqrt{1 - (f/f_c)^2} \quad .. \quad (20)$

(c) Mid-Shunt Characteristic Impedance.

The mid-shunt characteristic impedance has been shown to be given by (8), that is :—

$$Z_K' = \sqrt{\frac{Z_1 Z_2}{1 + Z_1/4Z_2}}$$

Therefore in the case of the filter of Fig. 22 it can easily be shown, by substituting for Z_1 and Z_2, that the impedance as measured between C and D, when the far end is properly terminated, is

$$Z_{CD} = \frac{Z_0}{\sqrt{1 - (f/f_c)^2}} \quad .. \quad (20a)$$

The Derived Low Pass Filter.

So far all the formulæ have been obtained by considering the simple filter of Fig. 22. By using the equations (11) to (15), inclusive, the corresponding formulæ for the more complex filter of Fig. 21 can be readily determined. From (14), (15), and (17), we have for the cut-off frequency of the derived filter :—

$$f_c = \frac{1}{\pi\sqrt{C_2/L_1 \times L_0^2}} = \frac{1}{\pi\sqrt{C_2(L_1 + 4L_2)}} \quad (21)$$

Mid-Series Characteristic Impedance.

From Fig. 21, we have that :—

$$Z_1 = j\omega L_1$$
$$Z_2 = j(\omega L_2 - 1/\omega C_2)$$

Hence $Z_1 Z_2 = -\frac{L_1}{C_2}(\omega^2 L_2 C_2 - 1)$

and $1 + \frac{Z_1}{4Z_2} = \frac{\omega^2 L_1 C_2 + (\omega^2 L_2 C_2 - 1)4}{4(\omega^2 L_2 C_2 - 1)}$

$\therefore$ Substituting in equation (1), we have that the series characteristic of the derived filter is given by :—

$$Z_K^2 = \frac{L_1}{C_2}\left[1 - \omega^2 C_2\left(\frac{L_1}{4} + L_2\right)\right]$$

$$= \frac{L_1}{C_2}\left[1 - \frac{\omega^2}{\omega_c^2}\right]$$

after employing equation (21).

From equations (11), (13) and (19a), we have :—

$$\frac{L_1}{C_2} = \frac{L_0}{C_0} = Z_0^2$$

$$\therefore \quad Z_K = Z_0\sqrt{1 - (f/f_c)^2}$$

This impedance is, as would be expected from the analysis on page 191, the same as that for the simple filter.

Frequency of Infinite Attenuation.

The frequency at which we have infinite attenuation for the derived filter will be denoted by f_∞.

Now it has been shown on pages 126 and 127 that when the value of the ratio of the impedance of the series arm to that of the shunt arm of any structure is positive, the attenuation is given by

$$A = 2 \sinh^{-1} \tfrac{1}{2}\sqrt{+ Z_1/Z_2}$$

When the value of the ratio lies between -4 and $-\infty$, the attenuation is given by

$$A = 2 \cosh^{-1} \tfrac{1}{2}\sqrt{- Z_1/Z_2}$$

Hence, in both cases, the value of the attenuation will be infinity when the value of Z_1/Z_2 is infinity.

Consider now Fig. 21. The value of the shunt arm is given by :—

$$Z_2 = j\omega L_2 + 1/j\omega C_2 = \frac{1 - \omega^2 L_2 C_2}{j\omega C_2}$$

The value of Z_2 will be zero, and hence the value of Z_1/Z_2 will be infinity, when

$$1 - \omega^2 L_2 C_2 = 0 \qquad \text{i.e., } \omega^2 = 1/L_2 C_2$$

The frequency of infinite attenuation is therefore given by :—

$$f_\infty = 1/2\pi\sqrt{L_2 C_2} \quad .. \qquad .. \quad (22)$$

We have therefore from equations (21) and (22) that

$$a = f_\infty/f_c = \sqrt{\frac{L_1 + 4L_2}{4L_2}} = \sqrt{1 + L_1/4L_2} \quad (23)$$

We have also from equations (11) and (12) that :—

$$m^2 = \frac{1}{1 + 4L_2/L_1} \text{ or } m = \frac{1}{\sqrt{1 + 4L_2/L_1}} \quad (24)$$

Combining (23) and (24), we have :—

$$m = \frac{\sqrt{a^2 - 1}}{a} \text{ or } a = \frac{1}{\sqrt{1 - m^2}} \quad .. \quad (25)$$

The ratio of the series and shunt impedances of the derived filter can also be expressed as follows :—

From Fig. 21 we have

$$Z_1/Z_2 = \frac{\omega L_1}{\omega L_2 - 1/\omega C_2} = \frac{\omega^2 L_1 C_2}{\omega^2 L_2 C_2 - 1}$$

Combining this expression with equations (11), (13), (17) and (22) we have :—

$$Z_1/Z_2 = \frac{4(f/f_c)^2 m^2}{(f/f_\infty)^2 - 1} = \frac{4m^2(f/f_c)^2}{(f/f_\infty)^2 - 1} \quad .. \quad (26)$$

Mid-Shunt Characteristic Impedance.

The mid-shunt characteristic impedance of the structure of Fig. 21, that is the impedance as measured between *E F* when the far end is correctly terminated, can be determined as follows.

From equation (1) we have that the mid-series characteristic of any structure is given by :—

$$Z_K = \sqrt{Z_1 Z_2 (1 + Z_1/4Z_2)}$$

And from equation (8) we have that the mid-shunt characteristic impedance of any structure is given by :—

$$Z_K' = \sqrt{\frac{Z_1 Z_2}{1 + Z_1/4Z_2}}$$

Hence by division we have that :—

$$Z_K' = \frac{Z_K}{1 + Z_1/4Z_2}$$

But from equations (25) and (26) we have that :—

$$Z_1/Z_2 = \frac{4(a^2 - 1)}{1 - a^2(f_c/f)^2}$$

$$\therefore \quad Z_K' = \frac{Z_K}{\dfrac{a^2 - 1}{1 - a^2(f_c/f)^2}}$$

$$= \frac{Z_K\left[1 - \left(\dfrac{f}{af_c}\right)^2\right]}{1 - (f/f_c)^2}$$

We have from equation (20) that :—

$$Z_K = Z_0\sqrt{1 - (f/f_c)^2}$$

therefore

$$Z_K' = \frac{Z_0[1 - (f/af_c)^2]}{\sqrt{1 - (f/f_c)^2}} \quad .. \quad (26a)$$

Determination of the Values of the Filter Elements.

By division we have from equations (17) and (19a) that

$$L_0 = Z_0/\pi f_c \quad .. \qquad .. \quad (27)$$

By multiplication we have from these two equations :—

$$C_0 = 1/\pi f Z_0 \quad .. \qquad .. \quad (28)$$

from equations (11), (25) and (27) we have :

$$L_1 = mL_0 = \frac{L_0\sqrt{a^2 - 1}}{a} = \frac{mZ_0}{\pi f_c} \quad (29)$$

Similarly from equations (12), (25) and (27) we have :—

$$L_2 = \frac{1 - m^2}{4m} L_0 = \frac{L_0}{4a\sqrt{a^2 - 1}} = \frac{Z_0}{\pi f_c} \times \frac{1 - m^2}{4m}$$

$$.. \qquad .. \quad (30)$$

And from equations (13), (25) and (28) we have :—

$$C_2 = mC_0 = \frac{C_0\sqrt{a^2-1}}{a} = \frac{m}{\pi f_c Z_0} \quad (31)$$

In the design of a low pass filter the available information generally includes (1) the cut-off frequency f_c, (2) the value of the terminal impedances between which the filter is to operate, and (3) an indication of the required attenuation characteristic, the latter being governed by the value decided upon for the frequency of infinite attenuation f_∞. As far as the terminal impedances are concerned these are generally pure resistances, and if they are the same at both ends of the filter the transmission loss caused by the filter in the unattenuated range will be a minimum provided the characteristic impedance of the filter has the same value as each of the terminal impedances. If from equation (20) a curve between Z_K/Z_0 and f/f_c is plotted, it will be seen that for frequencies not too close to the cut-off frequency the characteristic impedance of the filter remains reasonably close to that of Z_0. Hence, it is generally assumed that the Z_0 of a low pass filter should be approximately of the same order of magnitude as the terminal impedances between which the filter is operated.*

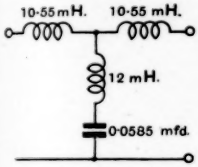

Fig. 23.

Example.

A numerical example will be given to illustrate the design of a low pass filter. Suppose that it is required to design a low pass filter which shall operate between terminal impedances of 600 ohms, that it shall have a cut-off frequency of 5,000 cycles per second, and that it shall have infinite attenuation at a frequency of 6,000 cycles per second.

Therefore, $f_c = 5{,}000$, $f_\infty = 6{,}000$, $Z_0 = 600$.

from (23) $a = \frac{f_\infty}{f_c} = \frac{6000}{5000} = 1.2$

from (25) $m = \frac{\sqrt{a^2-1}}{a} = 0.552$

from (29) $L_1 = \frac{mZ_0}{\pi f_c} = \frac{600 \times 0.552}{\pi \times 5000}$
$= 21.1$ milli-henrys.

from (36) $L_2 = \frac{Z_0}{\pi f_c} \times \frac{1-m^2}{4m}$
$= 12$ milli-henrys.

from (31) $C_2 = \frac{m}{\pi f_c Z_0} = 0.0585$ mfd.

The required low pass filter is therefore as shown in Fig. 23.

We shall now obtain the attenuation and phase constant characteristics for this filter.

From equation (26) we have that :—

$$Z_1/Z_2 = \frac{4m^2(f/f_c)^2}{(f/f_\infty)^2 - 1}$$

If we substitute the values for m, f_c and f_∞ in the above formula, it will be found that for all frequencies between 0 and 5,000 cycles per second, the value of Z_1/Z_2 always lies between 0 and -4. Hence, during this frequency range there will be no attenuation. At 5,000 cycles per second we have that $Z_1/Z_2 = -4$. At 6,000 cycles per second the denominator of the above equation is zero, and hence the attenuation will be infinite (see page 194).

Between 5,000 and 6,000 cycles per second the value of Z_1/Z_2 for any desired frequency can be obtained from the above equation.

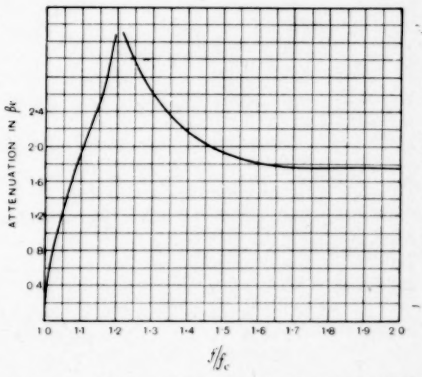

Fig. 24.—*Attenuation curve for low pass filter.*

It will be found that during this frequency range the value of Z_1/Z_2 will be negative, hence the corresponding attenuation can

* The question of filter terminations will be considered much more fully in Section G.

be read off from the curve for $\phi = 180°$ on Fig. 6 (see page 125).

For frequencies above 6,000 cycles per second the value of Z_1/Z_2 will be found to be positive, and hence the corresponding attenuation can be read off from the curve for $\phi = 0°$. The attenuation frequency characteristic for the filter is shown in Fig. 24. It is seen that the attenuation increases fairly rapidly for frequencies above the cut-off frequency. The rate of increase would be greater if the frequency of infinite attenuation were nearer the cut-off frequency and vice versa.

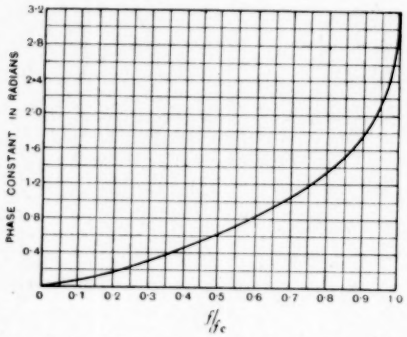

Fig. 25.—*Phase constant curve for low pass filter.*

Consider now the phase constant characteristic.

From the curves of Fig. 7 it is seen that for $\phi = 180°$ the phase constant remains constant at 3.14 radians, that is 180°, providing that the magnitude of Z_1/Z_2 is equal to or greater than 4. Therefore, for the frequency range between cut-off and the frequency of infinite attenuation, when the value of Z_1/Z_2 will be found to be more negative than -4, the phase constant will remain at 180°. It is further seen from Fig. 7 that for $\phi = 0°$ the phase constant remains at 0° for all values of Z_1/Z_2. Therefore, for all frequencies above the frequency of infinite attenuation, when the value of Z_1/Z_2 will be found to be positive, the phase constant will remain at 0°. For frequencies in the non-attenuation range, when the value of Z_1/Z_2 will be found to lie between 0 and -4, the phase constant will follow the curve shown in Fig. 25. The values for this curve have been obtained by calculating the value of Z_1/Z_2 from the above equation for any given frequency, and then reading off the corresponding value of the phase constant from the curve for $\phi = 180°$ on Fig. 7. There is always a phase shift of 180° at the cut-off frequency, the phase shift at any lower frequency being dependent on the value fixed for f_∞.

(*To be continued.*)

Threshold Howl in Reaction Receivers.*

By L. S. B. Alder, M.Sc.

IT is probable that most experimenters with short wave reaction receivers are familiar with the phenomenon known as threshold howl, but for those who have not made its acquaintance, it may be explained that in a reaction receiver with a circuit such as that shown in Figure 1, containing a leaky grid detector coupled by a transformer to one or more low frequency stages, it frequently happens that as the reaction is increased up to the oscillating point, a low frequency oscillation or modulation appears to start simultaneously with the high frequency oscillation, and to continue with a rise in pitch as the reaction is increased, until with a still greater increase in reaction, the low frequency modulation dies out leaving a pure high frequency oscillation.

Now, in a short wave receiver used for the reception of morse signals, whether C.W. or I.C.W., it is just at this point where threshold howl appears that the greatest sensitivity is looked for, but the smoother the reaction control and the better the adjustment of grid bias for good detection, the worse is the threshold howl likely to be, and what ought to be in practice an extremely sensitive

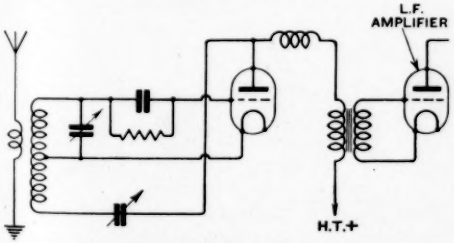

Fig. 1.—*Receiving circuit with reaction.*

telegraphic receiver, may become impossible to operate under anything like the best conditions.

The oscillations emitted from a valve producing threshold howl are similar in character to the self quenched oscillations which can be generated in a circuit of the same kind by making a large increase in the reaction beyond the oscillating point. In this case, the quenched oscillations are produced by the charging of the grid condenser during the building up of oscillations, and its subsequent discharge through the leak resistance. They consist of trains of damped high frequency oscillations, succeeding one another at a frequency governed by the rate of discharge of the grid condenser through its resistance, a large value of the time constant (CR) of this circuit corresponding to a low quenching frequency. That threshold howl does not proceed from the same cause can be proved by altering the value of the grid leak resistance which, in the case of self quenched oscillations, changes the audible note, but produces no change in the case of threshold howl. The cause of the latter must, therefore, be looked for elsewhere. In fact, the usual values of grid condenser and leak for good detection give a very high pitched self quenching note, whereas threshold howl is usually observed as a note of low pitch.

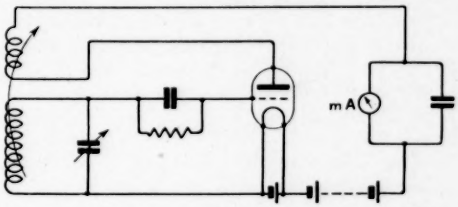

Fig. 2.—*Receiver circuit with milliammeter in the plate circuit.*

If a regenerative valve circuit is provided with a milliammeter in its anode circuit, and the reaction is gradually increased up to the oscillating point, it is generally found that there is a marked change in the mean anode current when oscillations commence. When a condenser and leak resistance are included in the grid circuit, such as in the circuit illustrated in Figure 2, there is usually a decrease in anode current when oscillations commence, though a further increase in reaction may give a subsequent increase in current. In the case of an anode bend detector, where the grid is given a permanent

*MS. received by Editor, March, 1929.

negative bias by means of a battery, or potentiometer, the building up of oscillations is usually accompanied by an increase in the mean anode current, although it may be possible to adjust the bias so that the anode current remains practically constant for quite a large increase in reaction beyond the oscillating point. In either case, however, the conditions which correspond to good autodyne detection are those which give a large change in anode current as reaction is increased just beyond the oscillating point, and with a leaky grid detector this change is a *decrease*, whilst with an anode bend detector it is an *increase*.

Suppose now, that the anode circuit of the regenerative detector contains an external impedance, as is always the case when it is followed by a low frequency stage. If the external impedance is a pure resistance, any change in anode current is accompanied by a change in potential on the anode of the valve which is in phase with the change in current, with the result that, as reaction is increased, oscillations build up in the tuned circuit simultaneously with the change in mean anode potential, until a steady state is reached in which the oscillations in the tuned circuit maintain a constant amplitude.

The conditions are quite different when the external impedance is inductive. With a leaky grid detector, the drop in current through the inductance as oscillations commence now causes an induced E.M.F. in the inductance which adds to the potential applied to the valve from the anode battery, with the result that the oscillations build up to a greater amplitude than can be maintained; for, directly the anode current ceases to fall, the additional induced E.M.F. is removed and the amplitude of the high frequency oscillations again falls. This in turn is accompanied by a rise in the mean anode current passing through the inductance, and a still greater drop in the anode potential and in the amplitude of the high frequency oscillations, which may even be shut down entirely.

It will be seen then, that the anode inductance acts in such a way as to supply energy during the time that oscillations are growing up, so that they attain temporarily an amplitude higher than can be maintained, and that during the subsequent fall in amplitude the inductance absorbs energy and causes a still greater fall in amplitude below the stable value. After this, the process is repeated and the amplitude of the high frequency oscillations swings alternately above and below the steady value. This effect is present in every regenerative valve circuit of the kind considered, namely, in which a decrease in the mean current through an inductive anode circuit accompanies the building up of oscillations in the tuned circuit, but it must not be supposed that every such circuit can be made to howl. In most cases the amplitude of each successive swing becomes smaller than the preceding one, and the swings are rapidly damped out before any effect can be observed in the telephones. In some cases, however, particularly when the anode inductance is large and capable of storing and restoring considerable energy, and when the change in the mean anode current with the amplitude of oscillations is large, the successive swings in amplitude will not die out but will continue to follow one another at definite intervals, giving the effect of a low frequency modulation on the high frequency oscillation.

The modulation frequency, which is observed as a howl, depends upon the time constant $\frac{L}{R}$ of the circuit, L being the value of the inductance in the anode circuit and R the total series resistance through which the current flows. The value of R, including as it does the valve impedance, is obviously not a constant quantity, since it is the variation of this impedance which is the primary cause of the variation in the current. A very much fuller experimental and theoretical investigation of the problem would be required before the modulation frequency could be calculated in any particular case, but it will be sufficient here to note that a decrease in the value of L or an increase in R may be shown experimentally to give a higher modulation frequency. The rise in pitch of the howl which is observed as the reaction is increased is, in fact, caused by the increase in the mean value of R as the grid becomes more negative, due to the high frequency oscillations building up to a greater amplitude with increasing reaction.

This, then, is the explanation of threshold howl as commonly observed, with a leaky grid detector, but it occurred to the writer that confirmation might be obtained in

another way, namely, from the behaviour of an anode bend detector having a capacity shunted across a resistance in its anode circuit. In this case the building up of oscillations is accompanied by an increase in the mean anode current, and the charged condenser in the external circuit should be able to supply this extra current temporarily, without the drop in anode potential which would occur if the current through the external resistance were increased instantaneously. This should cause the high frequency oscillations in the tuned circuit to build up beyond their final steady value, only to be followed by a swing through in the other direction, just as in the case of the leaky grid detector with an inductive anode circuit. A simple test with the circuit illustrated in Figure 3 showed this assumption to be correct, and the threshold howl was even more intense and persistent than with the leaky grid arrangement. With an anode resistance of 100,000 ohms threshold howl was observed with all values of shunt condenser between 0.001 mfd. and 2 mfd., the latter value of condenser giving a series of clicks rather than a howl. An interesting effect occurred when the shunt condenser was reduced below 0.01 mfd. It was then noticed that the reaction could be increased up to and beyond the oscillating point without any howl, but a further increase in reaction caused it to commence. With a condenser as small as 0.001 mfd., a very large increase in reaction was possible before the howl was started, and the note was then of a very shrill pitch.

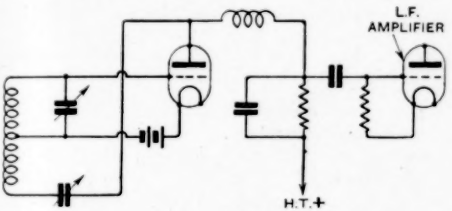

Fig. 3.—*Circuit used in tests.*

In the case of the anode bend detector, the time constant of the circuit governing the howl frequency is CR, where C is the shunting capacity and R is again dependent upon the variable valve resistance as well as upon the fixed anode circuit resistance. In this case, also, an increase in reaction is accompanied by a rise in pitch of the howl, for although the resistance factor now appears in the numerator of the time constant, an increase in reaction corresponds, with anode bend detection, to a decrease in the valve resistance.

It has been shown that threshold howl is likely to occur in a leaky grid detector with an inductive anode circuit, and in an anode bend detector with a capacity across its anode resistance. The case of either type of detector with an anode circuit containing a capacity shunting an inductance is of interest, for a parallel circuit of this kind acts as an inductance to frequencies below its resonance point and as a capacity to frequencies above this point. The reactance of such a circuit is equal to that of the inductance branch at very low frequencies, and increases with frequency to a maximum positive value just below the resonant point, after which it reverses and attains its maximum negative value just above resonance. With a further increase in frequency the negative value of the reactance decreases until, at very high frequencies, it becomes equal to the reactance of the condenser branch. Thus, when an inductance in the anode circuit of a leaky grid detector is shunted by a condenser, a threshold howl may be observed to commence as a low pitched note, but with increasing reaction the pitch of the note rises more slowly than it would do in the absence of the condenser, and can never rise to a higher pitch than the resonance frequency of the circuit. Similarly, in an anode bend detector associated with an anode circuit of this kind, no threshold howl can commence at a frequency lower than the resonance frequency of the circuit, since the anode circuit is inductive for such frequencies. If, by increasing the reaction, a high pitched howl is started, and the reaction is then reduced so as to produce an increase in the impedance of the valve, the lowering in pitch due to the increase in the resistance term of the time constant is almost completely offset by the decrease in the effective capacity of the circuit as resonance is approached. It is, therefore, not possible to prevent threshold howl by using a parallel circuit of this kind, but with the anode bend detector with, say, a shunted transformer in its anode circuit,

it should be fairly easy to avoid the occurrence of howl at the point where oscillations are just commencing, at which point the receiver will normally be operated.

Certain points in connection with receiver design emerge from the foregoing explanation of threshold howl. In the first place, it must be clearly understood that these remarks apply only to receivers which are to be worked in an oscillating condition or very near to the oscillating point. It is immaterial whether the detector valve is preceded by high frequency stages or not. The writer's tests have included simple detectors with reaction into the aerial circuit, and receivers with screened valves and neutrodyned triodes placed in front of the detector, both for the purpose of affording high frequency amplification, and of reducing aerial radiation. The only direct effect of adding high frequency valves which concerns the present discussion, is that they may contribute to the general background of noise which may be accentuated by any tendency to threshold howl as explained hereafter, and, of course, any low frequency feed back by way of the high frequency stages due, for example, to common resistance in the anode circuits, is also likely to increase the tendency to maintain a howl.

In the second place, a leaky grid detector followed by a choke- or transformer-coupled low frequency stage, or even with the inductance of a pair of telephones in its anode circuit, is always liable to threshold howl. Even if the phenomenon is not encountered as a continuous howl, every transient impulse given to the tuned circuit, whether received from the aerial due to atmospherics or other interference, or whether it is due to irregular emission of the valves within the receiver, will cause damped trains of oscillations which may not persist long enough to be audible as a definite note in the telephones, but which will nevertheless tend to make the receiver noisy in operation. The writer has frequently noticed that a detector valve has a tendency to be extremely microphonic when oscillating, although it may be perfectly quiet before oscillations start. The ringing due to the vibration of the electrodes is often very intense when the valve is oscillating. This effect has been found by experiment to proceed from the same cause, and the substitution of a resistance capacity coupling for a transformer after a leaky grid detector has in some cases entirely removed the microphonic effect.

Thirdly, all the usual types of oscillating circuit, and common methods of reaction control, seem to be equally liable to howl when associated with a leaky grid detector and an inductive anode circuit. A smooth reaction control usually produces the howl at its worst. When there is much backlash in the starting of oscillations the point at which a howl would be prominent is likely to be missed.

Anode bend detection, though known to be less sensitive than leaky grid for the reception of weak signals in a non-oscillating receiver, is not necessarily any less efficient when the receiver is used in an oscillating state for the reception of morse signals, and further, for this purpose the anode bend detector may well be followed by a transformer- or choke-coupled stage of low frequency amplification. Whatever type of coupling is used it is important that any condenser used for shunting high frequency currents in the anode circuit should not be larger than necessary.

Finally, it is concluded that, where a detector is used in an oscillating state, the most satisfactory arrangement is likely to be a leaky grid detector with a resistance capacity coupling to the first low frequency stage. Even with this arrangement care must be taken that the inductance of the anode circuit is not unduly increased by using a reaction coil or high-frequency choke of greater inductance than necessary for satisfactory reaction control, otherwise the receiver may be unnecessarily noisy. In a short-wave receiver for which this type of circuit is particularly useful, the inductance of the high-frequency choke need only be a negligible quantity in the promotion of threshold howl, and there is, in fact, no difficulty in designing a thoroughly efficient receiver on these lines.

The experimental work on which this article is based has been carried out at H.M. Signal School, Portsmouth, and the article is published with the permission of H.M. Board of Admiralty.

Some Developments of the Piezo-Electric Crystal as a Frequency Standard.

Paper by Mr. H. J. Lucas, A.M.I.E.E., read before the Wireless Section, I.E.E., on 5th March, 1930.

ABSTRACT.

THE first part of the paper deals with some errors observed in quartz resonators employed as frequency standards.

The author first defines the following conventions :—

(1) Longitudinal Vibrations—the mode of oscillation employing the longest dimension of the crystal.

(2) Transverse Vibrations—the mode of oscillation employing the thickness of the crystal, *i.e.*, at right angles to the longitudinal mode.

(3) Resonator—a crystal used non-reactively.

(4) Oscillator—a crystal used retroactively, or to control a retroactive circuit. The transverse mode is usually the more effective.

From the precision standpoint the longitudinal mode offers greater advantage, having a temperature coefficient of about 1/20 of the transverse.

Fig. 4.

Variations in the behaviour of crystal resonators—using the Cady crevasse as a reference—suggested investigation of the mounting of the crystal, and early experiments suggested friction as a source. As a remedy the resonator was mounted as in Fig. 4,* so that it was firmly gripped at a nodal point of mechanical displacement for the longitudinal mode, *i.e.*, in the centre of its length.

This effectively remedied short-period variations of frequency, but long-period variations of the order of 1 in 10,000 were still found. These were traced to changes in atmospheric humidity, which was confirmed by tests in a saturated atmosphere (when the piezoelectric effect disappeared) and by tests in a sealed tube with a desiccating agent. The latter gave definite stability after a slow drift during which the moisture was absorbed. The obvious step of evacuating the tube was then taken, and gave further anticipated improvement in decrement due to the removal of air-loading. It is doubtful whether evacuation or desiccation without the mounting precautions would be of much value, as the effects of frictional loading would largely mask the improvement due to the removal of air loading.

During the work on resonators it was found possible to develop a valve oscillator with a frequency constancy of 1 in 100,000, by attention to careful design of the variable condenser, and by using it across a fixed condenser as large as possible for the tuning range. A 10 kc. oscillator on this arrangement was built, followed by a power amplifier and the harmonic-producing circuit of Fig. 8. The 10th harmonic of the oscillator was selected by a tuned circuit and referred to a 100 kc. quartz resonator, while the output coil L gave a full range of harmonics from 10 to 2,000 kc.s in steps of 10 kc. Errors due to coupling were obviated by the reference to the 100 kc. resonator. This apparatus was found of very great use in the calibration of substandard wavemeters and for the measurement of inductances and capacities at various high frequencies.

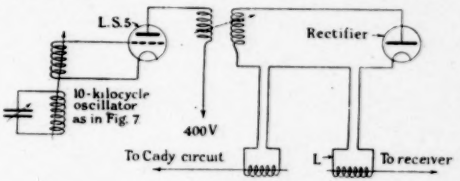

Fig. 8.

The author sums up the advantages of using a resonator as a reference standard as follows :—

(1) The resonator is not doing any work.

(2) Provided the "Cady crevasse" circuit is accurately tuned, the true period of the crystal-mount assemblage is obtained.

(3) Any variation in the electrical circuit is immediately obvious and is under complete control.

The second part of the paper deals with the crystal as an oscillator and describes the development of the Lucas Sullivan Quartz Crystal Standard, exhibited at the recent Physical Society Exhibition (*cf. E.W. & W.E.* of February, 1930). The drive system was tuned anode with the crystal between grid and filament. The possible circuital variations are discussed under the heads : (*a*) anode variable-condenser ; (*b*) anode-inductance variation ; (*c*) anode-potential variation ; (*d*) filament-potential variation ; (*e*) grid-potential variation. Variations that were observed led also to the investigation of the effects of humidity, considerations of which led to the use of the valve type L.S.5D in which the

* The Author's original figure numbers are adhered to throughout this abstract.

grid connection is made to a terminal on the glass envelope, thus eliminating the valve holder and cap from the grid circuit.

The laboratory standard described includes a bell jar and desiccator with Fleuss pump, vacuum gauges and an ether-type thermostat. The crystal is mounted directly on the fused-quartz insulating washer of the bell jar with the grid leak connected to the same terminal inside. The lead from this terminal goes direct to the grid connection on the glass envelope of the valve. The outside of the insulating quartz washer and the valve envelope are thus the only dielectrics which are subject to normal atmospheric conditions. From test curves given it is assumed that the frequency stability of the laboratory type is of the order of 1 in 10^6, and that the instability of the portable type of vacuo crystal is absent in the laboratory type.

The author then describes his crystal-controlled High-frequency Multivibrator, shown in Fig. 20. The multivibrator impedances are designed for 50 kc.s, the frequency of the crystal control. No difficulty has been experienced in working down to the 120th harmonic, *i.e.*, 6,000 kc.s. A well-constructed open-scale calibrated oscillator is used for harmonic identification.

It is considered, however, that further development of this high-frequency multivibrator is needed. It is becoming an urgent necessity to develop the drive of the multivibrator so that it can be utilised in the higher-frequency bands, of the order of 3×10^5, with its present accuracy when used at 5×10^4 kc.s. This will permit the harmonics at extremely high frequencies to be used as " drives " of high precision and stability.

The same drive principle was then used to control a low-frequency multivibrator. The complete circuit is given in Fig. 21, which shows the crystal, the high frequency and the low-frequency multivibrators. The low-frequency multivibrator is of the 1,000-cycle type and is impulsed and controlled by its 50th harmonic from the crystal circuit. The arrangement has all the features of the standard multivibrator, *i.e.*, a range of 1 to 6,000 kc.s in steps of 1 kc. Apart from the steps of 1 kc. of the fundamental on the low-frequency side, a number of others on either side of this value are obtainable by adjustment of the coupling or of the variable condenser. These are the fundamentals obtained by impulsing successive harmonics. About twelve of these are available in the steps

$$\frac{f}{n-6} \cdots \frac{f}{n-1} \cdots \frac{f}{n} \cdots \frac{f}{n+1} \cdots \frac{f}{n+6}$$

where f is the control frequency of 5×10^4 and n is the normal impulsed harmonic frequency, *i.e.*, 50.

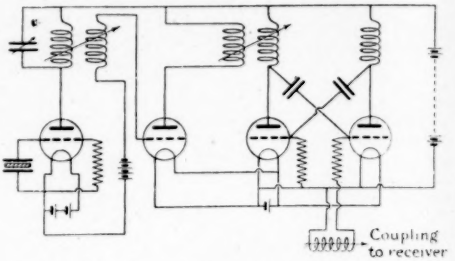

Fig. 20.

A suggestion to make use of this property is to employ a quartz drive at 50 kc. to control two multivibrators at frequencies of f/n and $f/n \pm 1$, where $n = 100$. The outputs will appear as 500 and 495 or 505 cycles respectively. These are to be combined and the resultant beats of 5 per second to be counted electrically over a period by photographic records at definite time intervals. This will provide a simple and direct reference to the time standard without the intervention of the usual phonic motor or similar device.

The apparatus was demonstrated during the reading of the paper, including the 5-cycle beat method just referred to.

A paper on " The Valve Maintained Quartz Oscillator," by J. E. P. Vigoureux, M.Sc.—which had already appeared in the February issue of the *I.E.E. Journal*—was also read (in abstract) and both papers were discussed together.

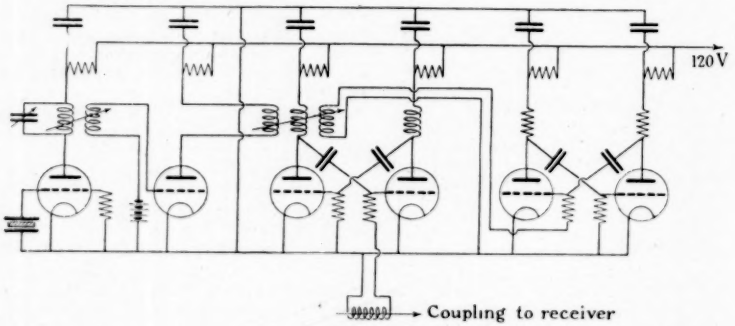

Fig. 21.

Discussion.

In opening the discussion, AIR-COMMODORE A. D. WARRINGTON-MORRIS referred to the modern need for many channels and to the importance of maintaining constancy of frequency. In the case of aircraft the high degree of accuracy was not yet as important as limitation of bulk. Was it yet possible to use the longitudinal mode of vibration directly on short waves?

DR. D. W. DYE said that Mr. Lucas had produced a better standard than any other available in this country. He was greatly interested in the method of getting a 5-cycle reference. Although there were obvious difficulties it was well worth carrying on with. He, too, had found effects from humidity and had used a bell jar and desiccating agent. As regards mounting, he had used a node on a knife-edge support and had got very low decrement. In using the resonator for frequency check he preferred to use the method of measuring the current into the crystal. This gave very good results. As regards the reaction which was inherent with the triode, he suggested the use of a screened-grid valve with deliberate control of the reaction introduced. Finality had not yet been reached in other methods of control, and by attention to details of tuning fork he had succeeded in reducing variations to such a degree as to give as good results as a crystal.

PROF. E. MALLETT referring first to Mr. Vigoureux's paper, offered some criticism of the mathematics and suggested the use of circle diagrams. As regards the change of frequency with humidity he questioned whether this was due to change of decrement and suggested that it might be due to change of mass.

MR. C. O. BROWNE asked for information on the mounting of the resonator, in particular as to whether Mr. Lucas had mounted the crystal in the node, but with the cork at the sides of the crystal. He also asked for information as to the possibility of using a resistance in the valve anode instead of an oscillatory circuit.

MR. B. WILLIAMS dealt particularly with the 5-cycle method of reference (for the suggestion of which he had been responsible). The method was difficult in practice on account of the large number of variables. Some of these had been tracked down and he hoped to be able to improve the method.

The authors briefly replied to the discussion and the meeting terminated with votes of thanks proposed by the Chairman, Capt. C. E. Kennedy-Purvis, R.N.

Correspondence.

Letters of interest to experimenters are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

The Losses in Air Condensers.

To the Editor E.W. & W.E.

SIR,—With reference to your editorial in the December 1929 issue of the *E.W. & W.E.*, it seems to the writer that the formula for the resistance of a variable air condenser is derived in a questionable manner. The loss due to dielectric hysteresis *per unit of volume* is proportional to the square of the electric field intensity; hence it would seem that the initial expression should be $W = a\omega V^2 C$ and the latter expression should be $R = \frac{a}{\omega C}$, which is correct for a condenser of solid dielectric but not for a variable air condenser.

In the case of a variable air condenser it is assumed that the condenser is comprised of a fixed capacity of solid dielectric in parallel with a variable capacity of negligible loss. If the fixed capacity is c, the total capacity C and the total current I, the current in the fixed capacity is $\frac{c}{C}I$, and the loss $\left(\frac{c}{C}\right)^2 I^2 \frac{a}{\omega c}$. Hence the resistance $R_e = \frac{\beta}{\omega C^2}$ where β = constant.

JOHN M. MILLER.

Atwater Kent Mfg. Co.,
4700, Wissahickon Ave.,
Philadelphia, Pa.
4th February, 1930.

[Mr. Miller arrives at the same result as that given in the editorial but by a different, and, in our opinion, more roundabout process of reasoning. We do not see what it is in our simple method that Mr. Miller regards as questionable. We assumed that the amount of solid dielectric in the electric field of the condenser was constant and that the loss in it was therefore $a\omega V^2$ where a is some constant. If C is the total capacity of the condenser $I = \omega CV$, and if a resistance R is to be determined, which, connected in series with the condenser, would cause the same losses as actually occur in the dielectric, then I^2R or $(\omega CV)^2R$ must equal $a\omega V^2$, from which it is seen that R must equal $a/\omega C^2$. We do not think that the result can be obtained in a more direct or less questionable manner.—G.W.O.H.]

The Absorption Method of Capacity and Inductance Measurement.

To the Editor, E.W. & W.E.

SIR,—Mr. A. P. Castellain, in his article in the February issue of *E.W. & W.E.*, omits to mention the very simple and accurate two-generator method of capacity measurement described by the writer in an article in the August 1928 issue of this journal. Two-valve generators, neither of which need be calibrated, are employed. One is left untouched throughout the test and the calibrated variable condenser of the other is reduced in value by a known amount to produce the same condition of heterodyne beating before and after connecting the capacity to be measured in parallel with it. Detection by *exact* heterodyne beat note matching is both convenient and accurate and, moreover, the method can be instantly extended

to the *precise* measurement of small capacities, as explained in the writer's article.

It should, perhaps, be noted that if the measurement is being made at low wavelengths, the leads by which the condenser being tested is connected to the calibrated condenser should be as free from inductance as possible consistent with a high degree of permanence of capacity between them. This, of course, applies equally to the absorption method. It is safer to make the determination on a circuit (either generating or absorbing) whose total inductance is of a value such that the lead inductance is quite neglible.

The difficulties met with in the measurement of small capacities, upon which Mr. Castellain remarks, will also be found dealt with fully at the commencement of the same article.

In methods of measurement of self-capacity and effective inductance of a coil such as those described by Mr. Castellain, which involve the measurement of wavelengths, the accuracy is very low, unless the wavemeter is an extraordinarily good one. The value of $C + c$ is determined in terms of wavelength and its percentage *inaccuracy* is therefore twice that of the wavemeter. It will be seen, therefore, that inaccuracies of the order 0.2 per cent. to 0.5 per cent. in the value of $C + c$ are quite possible, even if one uses a reasonably good wavemeter, and such inaccuracies have a very serious effect upon the value of c only.

These uncertainties are eliminated by the method described by the writer on page 458 of the August 1928 issue, and this method can be extended to the determination of self-capacity and effective inductance of a coil in a simple non-generating resonant circuit by inducing into the latter from a power generator which is tuned successively to various harmonics of a constant wavelength to which an independent heterodyne wavemeter is set. The determination of c is then independent of wavelength, merely depending upon the *exact* knowledge of the ratio of successive harmonic frequencies. If, for example, the successive harmonics are $\lambda/6$ and $\lambda/7$

$$c = \frac{6^2 C_6 - 7^2 C_7}{7^2 - 6^2}$$

where C_6 and C_7 are the corresponding successive resonance readings of the calibrated variable condenser with which the coil is associated.

W. H. F. GRIFFITHS.

[Dr. Leonard A. Sayce asks us to draw attention to the fact that he was probably the first to apply the absorption method of capacity measurement, and in 1925 devised a new method of measuring the dielectric constants of liquids, which enabled him to measure capacities readily to 0.005 micro-microfarads. [See *Journal Chemical Society*, 127 (1925), p. 315.] A further development of the method to measure the losses of small condensers was described in the *Journal of Scientific Instruments*, III (1926), p. 116. (See also *Journal Chemical Society*, 1926, p. 2623.)—ED.]

The Relation between Electric and Magnetic Fields.

To the Editor, E.W. & W.E.

SIR,—I have been, at various times, very much pleased by the spicily informative and happily phrased editorials of your talented editor, and I hope that I may never in any measure discourage him; nevertheless, I simply must engage him in argument concerning his latest editorial in the February *E.W. & W.E.*, entitled "The Relation Between Electric and Magnetic Fields," particularly as regards those passages where he ascribes E.M.F.s as *due* to *magnetic* fields, and where he speaks of *alternating* fields of one kind *without* the presence of fields of the other kind. I think neither is true.

I presume we may accept as valid the Lorentzian formulation of electromagnetic theory contained in the five following vector equations (Gibb's notation, Gaussian units),

$$4\pi I + \frac{\delta E}{\delta t} = c \text{ curl } H \quad .. \quad .. \quad .. \quad (1)$$

$$- \frac{\delta H}{\delta t} = c \text{ curl } E \quad .. \quad .. \quad 2)$$

$$\text{div. } E = 4\pi\rho \quad .. \quad .. \quad .. \quad .. \quad (3)$$

$$\text{div. } H = 0 \quad .. \quad .. \quad .. \quad .. \quad (4)$$

$$F = E + \frac{v \times H}{c} \quad .. \quad .. \quad (5)$$

where
E = elect. field.
H = mag. field.
I = current density.
ρ = charge density.
c = vel. of light.
v = electron or charge velocity.
F = force acting upon an electron.

And I further presume we may identify electricity with electrons and the currents in conducting bodies with electron motions so that the driving E.M.F.s producing currents in radio antennas will be due to line integrations of the fields acting on electrons themselves.

Equation (5) above gives the "actual" or "driving" force acting upon an electron, this force consisting of two parts. The first part, or "E," is equal to the electric field itself and acts in the direction of this field. The second part, or $\frac{v \times H}{c}$, is the vector product of electron velocity by magnetic field and is due to the magnetic field only, acts only when the electron is in motion, and acts *perpendicularly* to both the *direction* of motion and the *magnetic* field. When, therefore, the conducting body is a long, fine metal wire, the only direction of motion left, substantially, to the electrons of current flow is *along* the wire. But since the magnetic field acts only on *moving* electrons, and then at right angles to the motion, the only effect of the magnetic field is to crowd the moving electrons slightly to one side of the conductor. Accordingly it is, in all strictness, incorrect to state that the magnetic field ever *produces* a driving E.M.F. in an antenna; such E.M.F.s are *only* produced by electric fields. This statement holds equally well against the old rule that a rate of cutting of magnetic flux linked with a circuit *produces* an E.M.F.

Doubtless these two statements will horrify many engineers, and for my own safety's sake I hurry on to the next and explanatory paragraph. Equation (2) above connects the rate of change of

magnetic field *at a point* with the "curl" or "spin" of the electric field at that point. If, therefore, we select an arbitrary surface bounded by an equally arbitrary closed curve and integrate this equation over the surface we shall obtain a relation between the total magnetic field change over this surface and a total electric field "spin" for the same surface. Or,

$$-\int\frac{\delta H}{\delta t}\,.\,ds = c\int \text{curl } E\,.\,ds \quad .. \quad .. \quad (6)$$

But by the famous theorem of Stokes the line integral of a vector field around a closed curve is equal to the surface integral of the curl of this same vector over *any* surface bounded by this curve. Which is, in mathematical form, equivalent to

$$\int E\,.\,dl = \int \text{curl } E\,.\,ds \quad .. \quad .. \quad .. \quad (7)$$

and substituting this in (6) gives,

$$-\int\frac{\delta H}{\delta t}\,.\,ds = c\int E\,.\,dl \quad .. \quad .. \quad (8)$$

and if the closed curve is stationary—*i.e.*, does not vary with time—we have

$$c\int E\,.\,dl = -\frac{\delta}{\delta t}\int H\,.\,ds \quad .. \quad (9)$$

which we may put into words as follows: "The line integral of electric field (or total E.M.F.) around a stationary closed curve is equal to the negative of the rate of change of the total magnetic flux linked by, or transecting, this surface." This is our old friend of "flux cutting" days, and, since no particular surface or closed curve was taken, the theorem is quite general and limited only by the assumptions already mentioned.

The joker is easily located. The theorem states only that these two quantities are equal, their numerical values being *always* the same; it does *not* state that an E.M.F. is *produced* by a magnetic flux cutting. In most electric power problems this statement could be dismissed as a mere quibble; it cannot be so dismissed in homopolar induction theory, and in radio theory it must be kept distinctly in mind. Otherwise we shall have repetitions of pronouncements such as "Loops are magnetic antennas; open wires are electric antennas"—a statement which I have seen somewhere. When we shield an apparatus electrostatically, as with open mesh, screen, etc., we are, by means of this metallic screen, arresting every electric flux component which is unclosed on itself, which can begin and end upon conductors. We do *not* readily thus arrest "closed" or spinning electric fields (which are *always* accompanied by magnetic fields in numerical proportion); these pass through mesh holes, and especially cracks, and register themselves within, upon *closed* circuits. We then say "there is poor magnetic shielding," though it is not a magnetic but a spinning electric field which eludes us; a shielding against this we obtain only by means of a completely closed metallic envelope. But if this envelope be too thin the eddy currents resulting from the electric fields on the outside will penetrate through it and we shall have, again, electric fields inside the shield, due to the interior surface currents of the shield itself.

One final point. The theorem of Eq. (9) is valid for closed circuits only; it becomes nonsensical for open ones. This does not prevent the use of the numerical flux-cutting relation if one is willing to adopt additional rules for procedure. One such occurs in the Dellinger article of Bureau of Standards Scientific paper, 354, "Principles of Radio Transmission and Reception with Antennas and Coil Aerials," p. 446, Dec., 1919, where the rate of flux cutting of an open antenna is ruled to be equal to the antenna height times the "relative motion of the magnetic field" with respect to the conductor, or "$c\,h$," where "c" is the velocity of light and "h" the antenna height. The fact is, of course, that the magnetic field is not moving anywhere. But setting up "shop rules" is one thing and strict theory is another. One can always doctor up a formula if this appears desirable, but only strict theory can keep the thinking clear.

As an example, take the ordinary closed or "loop" antenna. If, as usual, it is small compared with the wavelength, we have induced on one side the voltage nEh, on the other side the voltage $nh\left(E+\frac{\delta E}{\delta l}\,dl\right)$; we subtract these two effectively and find the loop E.M.F. to be $nh\frac{\delta E}{\delta l}\,dl$. Thus, the open antenna operates on the electric field, the closed one on the rate of space change of electric field; it is an electric field differentiator. The symbols used are:

n = loop turns
h = height
l = length dimensions
} of loop.

Clearly this notion is, in theoretical aspect, different from that one based on a total linked magnetic flux cutting.

To sum up, the strict theory indicates that a magnetic field does not substantially affect antenna electrons; its use is confusing in radio work. The "flux cutting" rule of power theory is a numerical relation only; an open antenna theory *via* flux cutting is a doctored-up product, and we are back to the forgotten theorem of electrostatics that electric fields alone affect electric charges. I know of no radio reception to date which has derived from the magnetic field component of the radiation; there is a possibility that some magnetostriction effect, or accessory action in high permeability alloys (permalloy) may make magnetic field reception possible sometime; such apparatus would very likely be useful in studying nontransverse radiation fields such as the Zenneck-Sommerfeld "ground wave."

As regards the absence of electric or magnetic fields when varying magnetic and electric fields respectively exist, Equations (1) and (2) deny such a possibility at once. The coexisting fields may not be "open" ones, they may be closed "spinning" ones, but the *type* of field is not relevant so long as *a* type exists. Under no circumstances, in a stationary situation, can magnetic or electric fields vary *in any manner* without being accompanied by electric and magnetic fields respectively.

CARL R. ENGLUND.
54, Court Street, Freehold, N.J.
15th February, 1930.

Abstracts and References.

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PROPAGATION OF WAVES.

Sur l'Absence d'Échos retardés pendant la Totalité de l'Éclipse du 9 Mai en Indo-Chine (On the Absence of Long-time Echoes during Totality of the Eclipse of 9th May, in Indo-China).—C. Stôrmer. (*Comptes Rendus*, 13th Jan., 1930, Vol. 190, pp. 106–107.)

A reply to Ferrié's suggestion (March Abstracts, p. 151), that the cessation of long-time echoes during totality is contrary to Stôrmer's explanation of these echoes. The writer points out that at Poulo Condore (where the observations were made) the reflecting electronic surfaces beyond the moon's orbit are situated near the zenith. If, therefore, the refractive properties of the atmosphere are symmetrical with regard to the vertical, the signal rays can reach these surfaces fairly regularly; during the eclipse, however, the refraction indices are completely upset and rays approaching the vertical are liable to be deviated and deformed so that they cannot reach the reflecting surfaces. This would also explain the irregularity of the echo phenomena at the approach of twilight. However, prolonged observations are needed, at localities as favourable as Poulo Condore, to decide the correctness of this explanation.

Geometrical Optics in Absorbing Media.—P. S. Epstein. (*Proc. Nat. Acad. Sci.*, Jan., 1930, Vol. 16, pp. 37–45.)

A mathematical investigation (prompted by Van der Pol) into the propagation of rays—electromagnetic or of other types—in a medium of variable absorption and refraction. The writer deals first with rays in a transparent medium, starting from the Fermat principle of shortest time and proceeding on the lines of Hamiltonian theory, using the Jacobi method to obtain the final expression for the equations of a ray in such a medium. He then considers a ray in an absorbing medium, using a group of waves of different orientations in order to determine the path of the energy; as the experimental physicist uses a diaphragm to obtain a pencil of rays, so the writer obtains his pencil of rays by means of Huyghens' principle.

His results can be indicated by the following "examples of application":—Considering a stratified medium, *i.e.*, a medium in which the index of refraction is a function of the coördinate z only; and assuming that the rays lie in the (x, z) – plane, the resulting two-dimensional problem is dealt with as follows:—from the "equation of the iconal" (of the form $(\nabla S)^2 = n^2$, where S is the phase of the wave) he obtains the equation

$$\left(\frac{\partial S}{\partial x}\right)^2 + \left(\frac{\partial S}{\partial z}\right)^2 = n^2(z),$$

whose solution is $S = \alpha x + \int \sqrt{n^2 - \alpha^2}\,.\,dz$.
Applying this to the case of radio waves, which start in the non-absorbing lower layers of the atmosphere where α is real, he obtains

$$\frac{dx}{dz} = Re\,.\,\frac{\alpha}{\sqrt{n^2 - \alpha^2}}$$

In the case of the index of refraction decreasing with height, there is a fundamental difference between transparent and absorbing media: (1) if the medium is transparent, the ratio dz/dx decreases with height until it becomes equal to zero for $n = \alpha$. The rays describe an arc, reaching their maximum height at this elevation, and bend back to earth. This is the well-known phenomenon of total reflection; (2) if the medium is absorbing $(n^2 = \kappa + i\sigma)$, the ratio dz/dx has always the same sign; the ray goes up monotonically *without ever bending round and coming down; the rays which come down from absorbing layers are not totally- but partially-reflected waves.*

As long as the absorption is small ($\sigma \ll \kappa$) there is not much difference between cases (1) and (2); the primary rays become almost horizontal and produce a strong reflection only in this part of their path, while the secondary, reflected rays have here almost the same direction as the primary ones. It seems, however, that in the upper layers of the atmosphere the conduction and absorption are quite considerable; "a further investigation is therefore desirable, dealing with the intensity and path of reflected rays."

The equation quoted above contains the law of refraction for rays passing from a homogeneous transparent medium (n_0) into a homogeneous absorbing medium $(n^2 = \kappa + i\sigma)$. If the angle of incidence is β_0 (angle between ray and normal to the surface of discontinuity in transparent medium), the geometrical meaning of α is $\alpha = n_0 \sin \beta_0$. The corresponding angle in the second medium is given by

$$\tan \beta = \alpha \sqrt{\frac{\kappa - \alpha^2 + \sqrt{(\kappa - \alpha^2)^2 + \sigma^2}}{2(\kappa - \alpha^2)^2 + 2\sigma^2}}.$$

This formula shows that the deviation from the ordinary law of refraction is noticeable only when the absorption is appreciable in a thickness equal to one wavelength.

Multiple Signals in Short-Wave Transmission.—T. L. Eckersley. (*Proc. Inst. Rad. Eng.*, January, 1930, pp. 106–122.)

Author's summary:—"This paper presents an analysis of the facsimile records obtained recently in the transmissions between New York, U.S.A., and Somerton, England. Since the speed of the scanning spot in the facsimile apparatus is accurately known, these records permit the measurement of the time intervals between the various signals which produce the distortion in the received record (*cf.* Rukop, March Abstracts, p. 153). Thus the facsimile apparatus can be used as an oscillograph for Kennelly-Heaviside layer measurements after

the method employed by Breit and Tuve and others. The results of the analysis confirm, in general, the results of other experimenters and extend them in the direction of giving information as to the angle within which the useful radiation is confined at the transmitter. A knowledge of this angle is then shown to yield important information on the distortion to be expected on different wavelengths."

At the end of his paper the writer summarises his conclusions as follows:—The controlling factor determining signal strength at night is electron limitation and not attenuation, and to complete the theoretical aspect we should give reason why the attenuation appears to be negligible at night. The reason appears to be that the attenuating layer (100 km.) rises at night, effectively increasing τ perhaps tenfold; also N decreases, both of which factors decrease attenuation.

Summarising, we may say that the picture transmissions indicate the presence of four or five or even, in extreme cases, six separate rays between New York and Somerton (on 22 m.).

From the measured delay time between the echoes we may state that the maximum angle of elevation of the rays is 35 deg. in all but exceptional cases, and that the main energy is transmitted along rays of less than 20 deg. elevation, *i.e.*, practically glancing incidence.

The maximum daylight density in the upper layer is approximately 8.3 to 9.3 $\times$ 10^5 electrons per cu. cm., which corresponds to a daylight minimum wave of 8.6 m.

The total echo delay (between first and last signal) decreases rapidly with the wavelength, being 1 millisec. at 16 m. and decreasing to zero at 8.6 m.

With less certainty we may conclude that

(1) Transmission takes place by multiple reflections between earth and Heaviside layer, the latter being fairly sharply defined—for this [22 m.?] wavelength— at a height of 340 km.

(2) In the daytime attenuation takes place in the lower layer (100 km. height) and is practically proportional to λ^2.

(3) Throughout the night the attenuation proper ceases to play an important part, but the limiting wavelength increases (on account of recombination) from 8.6 to nearly 20 m. in extreme cases of long winter nights.

THE CRITICAL FREQUENCY IN AN IONIZED MEDIUM. STEADY MAGNETIC FORCE PRESENT.—T. L. Eckersley. (*Phil. Mag.*, Feb., 1930, Vol. 9, No. 56, pp. 225–232.)

A sequel to a recent analysis (Phil. Mag., Vol. 4, July, 1927) of the transmission of electromagnetic waves of frequency ν through an ionised medium, in which the critical frequency given by $\nu_0^2 = \frac{Ne^2c^2}{\pi m}$ was examined; the present note investigates the effect of the presence of a steady magnetic field. In this case the critical frequency is altered; the purpose of the note is to show that the momentum balance is the same as in the previous case and that the waves are brought to a standstill for the same reason, *i.e.*, the transference of the wave momentum to the ions. In investigating the motion of the ions in the field of the electric wave, the action of the magnetic force in the wave is taken into consideration, as this alone provides the necessary forward momentum to the ions. Elastic forces of restitution and frictional effects are however neglected.

The simple case in which the external magnetic force R is parallel to the ray is first investigated. In this case the wave splits up into two circularly polarised components, each of which travels with its appropriate group and phase velocity and can therefore be dealt with separately. A vibrational differential equation is deduced for the motion of the ion or electron, from the solution of which the mean forward momentum supplied to the ions can be deduced. To a first approximation the ionic momentum produced is found to be a definite fraction of the wave momentum supplied. The rate of increase of momentum at the head of the wave is $\frac{Z_0H_0}{2\pi c} \cdot \frac{u}{c}$ (u group velocity, Z_0 and H_0 amplitudes of electric and magnetic forces in wave).

The momentum conditions can only be simply calculated when u and c do not differ much. On this assumption the deficit in æthereal momentum is found to be identical with the gain in ionic momentum, to a first approximation.

u is then allowed to tend to zero and it is concluded that the group velocity of the wave $\rightarrow$ o on account of the demand for momentum of the ions which tend to rob the wave of all its momentum (in the neighbourhood of ν = initial frequency) so that the wave can travel no farther. This investigation is important from the point of view of the transmission of waves in an over-dense medium, where N, the ionic density, is so great that $\nu_0 > \nu$. If in such a medium a sufficiently strong magnetic field is introduced, the medium becomes transparent.

In the case when the ray direction makes an angle θ with the direction of R, the above is not unique. It seems to the author "to follow quite definitely that the application of a sufficiently intense magnetic field to an over-dense medium will make the latter transparent for a finite range of angles in accordance with the dictates of the phase-velocity equations. This result has an important application in the case of the transmission of waves over the earth's surface . . . sufficiently long waves can penetrate the (Heaviside) layer when the earth's magnetic field is taken into account."

SHORT WAVE COMMUNICATION.—T. L. Eckersley and K. W. Tremellen: T. Nakagami. (*Engineering*, 20th Dec., 1929, Vol. 128, p. 823.)

Short summaries of two papers recently read at the World Engineering Congress in Japan.

RECHERCHES SUR LES PROPRIÉTÉS DIÉLECTRIQUES DES GAZ IONISÉS ET LA DÉCHARGE EN HAUTE FRÉQUENCE (Researches on the Dielectric Properties of Ionised Gases, and High Frequency Discharge).—H. Gutton. (*Ann. de Physique*, Jan., 1930, Vol. 13, pp. 62–129.)

This paper deals very fully with the writer's theory of quasi-elastic forces causing natural

periods of oscillation for the ions, and leading to resonance phenomena in an ionised gas (*see* Abstracts, 1928, p. 222; 1929, pp. 146, 204 and 385). As foreshadowed in the second of these references, he finds that the square of the resonance frequency is proportional to the $\frac{3}{2}$ power of the number of ions per cm^3. The first two chapters deal with the various experiments on ionised gases and the conclusions drawn: chapter III applies the theory to the phenomena of radio propagation, for long, medium and short waves. The last part of the paper deals with the sparking potential for high frequencies in a rarefied gas. The conclusions are :—below 200 m. the potential increases with the frequency; between 200 and 30 m. there is a pressure for which the sparking potential drops very suddenly. For this frequency zone, the law of variation of sparking potential with pressure depends, within wide limits, on the length of the tube and the nature of the gas. Below 30 m., the resonance phenomena discussed earlier interfere with the sparking potential and allow an easy passage of the spark at pressures so low that at low frequencies it would be impossible to make the spark pass.

OZONE IN THE UPPER ATMOSPHERE.—W. J. Humphreys. (*Science*, 10th Jan., 1930, Vol. 71, p. xii.)

The writer believes that the fact that the stratosphere is coldest over equatorial regions and becomes gradually warmer with increase of latitude is due to the varying thickness of the ozone layer, which has been shown to be thinner over the equatorial than over the arctic regions.

SCHEMA DI DISPOSIZIONE PER LA MISURA DELLA DENSITÀ DEGLI IONI NELL'ATMOSFERA (Apparatus for the Measurement of the Ionic Density of the Atmosphere).—L. Martinozzi. (*Nuovo Cim.*, Aug.–Sept., 1929, Vol. 6, pp. 320–324.)

A modification of the classical apparatus used by Langevin, Moulin and others, employed by the writer in recent researches.

SULLE BASI SPERIMENTALI DELLE MODERNE TEORIE SULLA PROPAGAZIONE DELLE RADIO-ONDE (The Experimental Basis of Modern Theory of the Propagation of Wireless Waves).—I. Ranzi. (*Nuovo Cim.*, Aug.–Sept., 1929, Vol. 6, pp. cxxix–cxl.)

A comprehensive survey reaching right up to 1929.

IONS IN THE UPPER ATMOSPHERE.—E. O. Hulburt. (*Proc. Inst. Rad. Eng.*, January, 1930, Vol. 18, p. 9.)

Summary only. "In order to explain the variations in the earth's magnetism, the ionisation in the levels of the atmosphere from 80 to 150 km. is assumed to be predominantly ions, rather than electrons. The ion densities for day and night all over the earth are calculated, and agreement is found with the absorption and downward reflection of the longer wireless waves, as far as the facts are known. The sunset longitude of the earth comes out to be about 2,000 volts positive with respect to the sunrise longitude. Due to the crossed electric and magnetic fields the ionisation above 150 km. rises at night. This reduces the rate of disappearance of the electrons in the high atmosphere and secures agreement with the night-time skip distances."

THE RELATION BETWEEN ELECTRIC AND MAGNETIC FIELDS.—G. W. O. H. (*E.W. & W.E.*, February, 1930, Vol 7, pp. 57–58.)

An editorial referring to Curtis' letter (1929 Abstracts, p. 590) and to subsequent correspondence. The history is given of the fallacy that in an electromagnetic wave the electric and magnetic fields are 90 degrees out of phase. The writer, however, points out that it is perhaps convenient and excusable to regard the induction of electromotive force in a frame aerial as due to the magnetic field of an electromagnetic wave, without any reference to the electric field; or the induction of electromotive force in a vertical open aerial as due to vertical electric field without any reference to the horizontal magnetic field of the wave; what must *not* be done is to imagine that only the one component is being utilised, and that if one could utilise both components one would get double the result.

AIR TRANSPORT COMMUNICATION.—R. L. Jones and F. M. Ryan. (*Journ. Am. I.E.E.*, Jan., 1930, Vol. 49, pp. 50–54.)

Abridgment only. Two sets of curves are given, one showing the microvolts per metre of signals received *in* an aeroplane as the distance increased from 3 up to 120 miles, the curves being for altitudes varying from 2,500 to 10,000 feet; the other giving the same information regarding signals received *from* an aeroplane. Frequencies used were 1,510 and 3,450 kc./sec. Another curve shows the received strength in an aeroplane of the 325 kc. waves used for weather service: little variation with altitude was found on these waves, but changes of terrain had considerable effect. The rest of the abridgment deals briefly with aircraft receivers and transmitters and with the ground station.

SOME MEASUREMENTS IN CORNWALL OF THE SIGNAL STRENGTH FROM 5XX.—J. H. Reyner. (*Journ. I.E.E.*, Jan., 1930, Vol. 68, pp. 181–184.)

Author's summary:—"In connection with the testing of wireless receivers, information was desired concerning the field-strength obtained from 5XX in Cornwall, this district being known to be poor from the point of view of wireless reception. An investigation was therefore carried out with the aid of portable equipment. This particular apparatus was simpler than that usually employed, but appears from the consistency of the results to be reliable [the rectified current in the anode circuit of the anode-bend detector valve was measured by a sensitive microammeter; the receiver was then switched over to a dummy aerial having the same characteristics as the actual

aerial system. In this circuit was included a coupling coil from a screened local oscillator, the output from which was adjusted to produce the same rectified current as before]. A curious effect was brought to light which appeared to be a radio shadow caused by the masts of the beam station at Bodmin. This gives rise to an interesting distribution of the contours in the Truro district.

"The general order of field-strength appears to coincide with theory up to this point, if due allowance is made for attenuation, but there is a rapid falling-off towards the extreme west of Cornwall." Thus at 280 km. the mean observed field-strength is 90.5 per cent. of the calculated, at 335 km. it is 71.5 per cent., while at 385 km. it has fallen to 26.3 per cent.

EMPFANGSVERSUCHE IN DER LUFT (Reception Tests in the Air).—(*Rad., B., F. f. Alle*, Oct., 1929, p. 463.)

A paragraph saying that aircraft tests made by the U.S. Bureau of Standards have shown that reception is much better at 4,000 m. height than at 100 m. It is best at 6,000 m. No details are given.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

A THEORY OF THE PERMANENT MAGNETIC FIELDS OF THE SUN AND EARTH: A CORRECTION.—Ross Gunn: Leigh Page. (*Phys. Review*, 15th Dec., 1929, Vol. 34, pp. 1621–1622.)

Referring to Gunn's paper (Jan. Abstracts, p. 36) Page has pointed out that earth currents arising from internal electric or gravitational fields crossed with a self-generated magnetic field tend to *magnetise* the earth rather than to demagnetise it as was assumed. "By attributing the observed field to electric and magnetic effects alone, ion-free paths of only 10^{-7} cm. are required, whereas the original current systems which were attributed to an inhomogeneous magnetic field indicated that free path lengths of 3×10^{-6} cm. were necessary. The qualitative features of the original theory are unchanged."

THE LIGHT OF THE NIGHT SKY: ANALYSIS OF INTENSITY VARIATIONS OBSERVED AT THE CAPE, AT CANBERRA AND IN ENGLAND.—H. S. Jones. (*Proc. Roy. Soc.*, January, 1930, Vol. 126 A, pp. 246–259.)

"The available evidence leads to the tentative conclusion that the non-polar aurora, though possibly distinct from the polar aurora, is intimately related to it, to the variations of the magnetic field of the earth and to the variations in sun-spot frequency."

TRAVELING WAVES DUE TO LIGHTNING.—L. V. Bewley. (*Journ. Am. I.E.E.*, Oct., 1929, Vol. 48, pp. 729–733.)

Abridgment only. The effect of the rate of cloud discharge and the initial distribution of bound charge on the shape and amplitudes of the travelling waves is dealt with.

GLOBULAR LIGHTNING.—E. W. Marchant. (*Nature*, 25th January, 1930, Vol. 125, p. 128.)

An account of a recent case of globular lightning which must have been produced inside the room where it occurred.

LIGHTNING.—Part II.—F. W. Peek. (*Gen. Elec. Review*, Dec., 1929, Vol. 32, pp. 691–695.)

CATHODE-RAY OSCILLOGRAPH STUDY OF THE OPERATION OF CHOKE COILS ON TRANSMISSION LINES.—K. B. McEachron, and CALCULATION OF VOLTAGE STRESSES DUE TO TRAVELING WAVES, WITH SPECIAL REFERENCE TO CHOKE COILS.—E. W. Boehne. (*Gen. Elec. Review*, Dec., 1929, Vol. 32, pp. 668–673 and 676–682.)

LIGHTNING LESS MYSTERIOUS.—(*Elec. World*, 1st Feb., 1930, pp. 253–258.)

An article based on various American workers' results during 1929. "Two direct strokes recorded as negative. Line surges are predominantly positive and therefore of induced origin. Gradients as high as 52 kv. per foot of tower height", etc. A list of papers is given.

PROTECTION OF ELECTRICAL CIRCUITS AND EQUIPMENT AGAINST LIGHTNING.—(*Miscell. Pub. Bur. of Stds.*, No. 95, September, 1929.)

THEORY OF A NEW VALVE TYPE LIGHTNING ARRESTER.—Slepian, Tanberg and Krause. (*Journ. Am. I.E.E.*, Jan., 1930, Vol. 49, pp. 34–37.)

Abridgment of the Institute paper on the arrester referred to in Feb. Abstracts, p. 95. The incorporation of small amounts of conducting material (lampblack or powdered metal) in the porous material has been found to reduce the breakdown voltage considerably (thus avoiding the tendency to shatter or puncture), while the cut-off voltage is unaffected.

PROPERTIES OF CIRCUITS.

SUR LA THÉORIE MATHÉMATIQUE DES AUTO-OSCILLATIONS (On the Mathematical Theory of Auto-Oscillations).—A. Andronow and A. Witt. (*Comptes Rendus*, 27th Jan., 1930, Vol. 190, pp. 256–258.)

Further development of the work dealt with in Jan. Abstracts, p. 40. Here the writer arrives at the periodic solutions of the system of differential equations: $\ddot{\xi} + \omega_s^2\xi = \mu f(\xi, \dot{\xi}; \eta, \dot{\eta}; \mu)$, $\ddot{\eta} + \omega_s^2\eta = \mu g(\xi, \dot{\xi}; \eta, \dot{\eta}; \mu)$, where μ is a parameter which can be chosen arbitrarily small, and $\dot{\xi} = \frac{d\xi}{dt}$, $\ddot{\xi} = \frac{d^2\xi}{dt^2}$, etc. Such a system occurs in a triode oscillator comprising two oscillatory circuits, taking normal co-ordinates and considering only the oscillations departing but little from the sinusoidal form. Among the results obtained, the writer derives three conditions which contain the

mathematical theory of a series of phenomena accompanying coupled auto-oscillations; in particular, the phenomenon known to the Germans as the "ziehen" effect.

SPRAWNÓSÉ DWU NASTRAJANYCH OBWODÓW SPRZEZONYCH (The Efficiency of Two Tuned Coupled Circuits).—C. Krulisz. (*Przeglad Radiotech.*, Nos. 15/16 and 17/18, Vol. 7, pp. 61–63 and 69–72.)

Author's summary:—In the case of two rigorously tuned coupled circuits there is a limiting value of efficiency which cannot be surpassed, even if the mutual induction be infinitely large. This limiting value increases with the ratio $\frac{\sigma_2}{\sigma_1}$ where σ_1 and σ_2 are the magnification factors of the two circuits respectively $\left(i.e.,\ \sigma_1 = \frac{\omega_r L_1}{R_1},\ \sigma_2 = \frac{\omega_r L_2}{R_2}\right)$. The efficiency can be sensibly increased if the two circuits are slightly detuned with respect to one another.

ON THE DAMPED OSCILLATION OF A CONDUCTOR IN A NON-UNIFORM MAGNETIC FIELD.—E. S. Keeping. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 16–22.)

NOTE ON THE STABILITY OF BALANCED HIGH-FREQUENCY AMPLIFIERS.—J. R. Nelson. (*Proc. Inst. Rad. Eng.*, Jan., 1930, Vol. 18, pp. 88–94.)

Author's summary:—The question of stability in a balanced or neutralised radio-frequency amplifier is considered for one stage. Experimental and theoretical curves are given for the amplification, including regeneration as the plate to control grid capacity is varied in a balanced or neutralised radio-frequency amplifier.

The results are discussed for n stages of an impedance-coupled amplifier by using the author's general equation for the limit of stable amplification $A_v < \sqrt{2g_m/n\omega C_g}$ obtained for one stage.

The desirability of using a new tube factor $\sqrt{g_m/C_g}$ to compare tubes designed for use in high-frequency amplifiers is also discussed.

APPLICATIONS OF THE METHOD OF ALIGNMENT TO REACTANCE COMPUTATIONS AND SIMPLE FILTER THEORY.—W. A. Barclay. (*E.W. & W.E.*, February, 1930, Vol. 7, pp. 59–65.)

An adaptation to these particular purposes of the Alignment principle, whose application to other Wireless problems the writer has often advocated (*e.g.*, Jan. Abstracts, p. 38). To be continued.

NOTES ON THE DESIGN OF R-F. BAND-PASS FILTERS.—C. J. Hirsch. (*Rad. Engineering*, Sept., 1929, Vol. 9, pp. 31–33.)

Mathematical treatment of band-pass filter design in reference to the screen-grid valve. The equations are derived in terms of circuit constants, resonant frequency, and frequency away from resonance.

CIRCUIT COMBINATIONS THAT PROVIDE SUBSTANTIALLY UNIFORM SIGNAL SELECTION.—E. A. Uehling. (*Rad. Engineering*, Nov., 1929, Vol. 9, pp. 23–29.)

An article on the use of band-pass filter circuits combined with tuned resonance circuits in cascade.

TUNING CIRCUIT LOSSES.—A. L. M. Sowerby. (*Wireless World*, 1st January, 1930, Vol. 26, p. 9.)

Discussing the sources of incidental dielectric loss in the high-frequency amplifier.

"Time and energy spent on determining the best winding for a coil are quite wasted unless a good deal of care is also devoted to keeping down the losses due to faulty dielectrics. . . . There is no advantage whatever to be had from the use of stranded wire if the dielectric losses are on the scale found for the "multi-pin" coil and its appurtenances, for in such a case the copper losses form so small a proportion of the total losses that even if they are doubled or halved the efficiency of the tuned circuit as a whole would hardly be affected."

Attention is drawn to the researches of S. Butterworth (*E.W. & W.E.*, April, May, July and August, 1926) which, carried out on a purely mathematical basis, did not attempt to allow for losses due to the coil former and the plug or other mount used.

The author shows graphically the dynamic resistances, calculated for copper losses only, in Litz-wound and solid-wire coils respectively, and compares them with the total dynamic resistance disclosed in a practical circuit incorporating, besides the coil, the multi-pin base, H.610 valve in ebonite holder and a 3-megohm leak shunted across the grid circuit. Results emphasise the need for paying the very closest attention to reducing the losses due to faulty dielectrics.

OSCILLATION POWER OUTPUT OF A TRIODE SYSTEM AND PRINCIPLE OF ITS OPTIMUM DESIGN.—PARTS II AND III.—E. Takagishi. (*Res. Electrot. Lab. Tokyo*, 1929, Nos. 264 and 266.)

Continuation of the work dealt with in 1929 Abstracts, p. 628.

O OBNIZANIU CZESTOTLIWOŚCI (Frequency Demultiplication).—J. Groszkowski. (*Przeglad Elektrotech.*, No. 1, Vol. 12, 1930, Radio Suppt., pp. 7–11.)

The writer shows the possibility of obtaining frequency demultiplication by means of a circuit involving a triode.

BEITRAG ZUR THEORIE FLÄCHENHAFTER WIRBELSTRÖME (Contribution to the Theory of Eddy Currents in Plane Sheets).—W. STEIDINGER. (*Arch. f. Elektrot.*, No. 2, Vol. 22, 1929, p. 153.)

NOTE ON EDDY CURRENT LOSSES IN THE SHEATHS OF RECTIFIER CABLES.—F. W. Carter. (*See* under "Subsidiary Apparatus and Materials.")

THE OPERATION OF MODULATORS FROM A PHYSICAL VIEWPOINT.—Peterson and Llewellyn. (*See* under "Transmission.")

THE CAPACITY EFFECT AND NATURAL FREE PERIOD OF A DIRECT-CURRENT ARMATURE.—J. C. Prescott. (*Journ. I.E.E.*, Jan., 1930, Vol. 68, pp. 185–191.)

TRANSMISSION.

EIN GEGENTAKTOSZILLATOR FÜR ELEKTRONENSCHWINGUNGEN (A "Push-Pull" Oscillator for Electron Oscillations).—H. E. Hollmann. (*Phys. Zeit.*, January, 1930, Vol. 31, pp. 56–63.)

The principle of "push-pull" oscillations may be extended to the Barkhausen-Kurz electron oscillator. On both sides of a positive grid two incandescent cathodes are arranged, each of which acts as a retarding electrode for the electrons emitted from the other which pass through the grid; thus anti-phase oscillations are produced in the cloud of electrons.

The advantages of the "push-pull" arrangement are:

(1) The increase in the intensity of the oscillations;

(2) The production of oscillations of still higher frequency.

Oscillations are produced even when the electron tube is of definitely asymmetrical construction; this result disagrees with the prevalent opinion that a symmetrical form of the electrodes is a necessary condition for the production of Barkhausen-Kurz oscillations.

A NOTE ON ULTRA-SHORT WAVES AND RADIATION FROM FREE ELECTRONS.—D. S. Kothari and D. V. Gogate. (*Indian Journ. of Phys.*, No. 2, Vol. 4, 1929, pp. 175–178.)

Yagi (1928 Abstracts, p. 519) obtained with the Magnetron waves of the order of 10 cm. conforming to the formula $\lambda = 2ct$ (c = vel. of light, t = electron-time from filament to anode). These oscillations appear to be due to electrons travelling in closed paths with frequency ν: this occurs if the magnetic field is so arranged that the electrons just fail to reach the anode and pass tangentially along its surface. If this critical field strength and the anode potential are known, the ratio e/m can be determined (*cf.* Kothari, 1929 Abstracts, p. 212):

$\lambda = 2ct = 2c\pi b\sqrt{\frac{2eV}{m}}$ where V is the anode potential and b the anode radius.

These electron oscillations are impressed on the oscillating circuit whose capacity consists of the valve capacity; small anode potential fluctuations are thus produced, which account for changes of the oscillating circuit current. During tests for the determination of e/m it was found that the anode current increases if the magnetic field is decreased from the critical value. This increase of anode current is larger than that caused by a corresponding increase of anode potential or decrease of filament current. It is suggested that the phenomenon is due to the influence of the space charge: this is confirmed by experiment.

EXPERIMENTAL TRANSMITTING AND RECEIVING APPARATUS FOR ULTRA-SHORT WAVES: CORRESPONDENCE.—E. C. S. Megaw: C. Whitehead: R. L. Smith-Rose and J. S. McPetrie. (*E.W. & W.E.*, December, 1929, and January, 1930, pp. 676–678 and 22.)

Correspondence on the paper by the last two writers, dealt with in January Abstracts, p. 42. Among the various points discussed, Megaw mentions the plan of introducing both grid and anode d.c. supply at the nodal point of the inductance by the introduction of a stopping condenser of low impedance—the only single LC circuit arrangement which avoids making any d.c. connection to a point of high alternating potential; it introduces, however, difficulties of its own. He has had good results—improved purity and stability of heterodyne note (as compared with the usual centre-tap)—by using an adjustable nodal tap for anode supply, the grid being supplied directly through a choke. A small variable grid condenser, combined with this adjustable tap, gives a very satisfactory bridge balance position.

Whitehead mentions the use of metallic foil for coating the outside of small power valves, not merely as a preventive of possible puncturing of the glass but to decrease the lower limit of wavelength obtainable. Thus a DET1SW valve, with 60 per cent. of the surface coated, worked efficiently at 2.7 m., whereas without the coating 4.5 m. was the lowest wavelength obtainable.

THE PRACTICAL SHORT WAVE LIMIT OF TRIODE VACUUM TUBE OSCILLATORS.—S. Uda. (*Tech. Rep. Tôhoku Imp. Univ.*, Vol. 8, No. 4, 1929, pp. 89–95 and Plates.)

Barkhausen-Kurz type oscillations are excluded. For ordinary commercial valves the writer concludes that the limit of shortness of wavelength lies between 3.5 and 1.1 m. For small power valves a 2–4 m. range can be handled easily. A single variable air condenser, in the grid circuit, provides a convenient means of varying the wavelength generated. Other methods are mentioned, but this seems to give the smoothest and most stable adjustment.

THE OPERATION OF MODULATORS FROM A PHYSICAL VIEWPOINT.—E. Peterson and F. B. Llewellyn. (*Proc. Inst. Rad. Eng.*, Jan., 1930, Vol. 18, pp. 38–48.)

Authors' summary:—"The mathematical expressions which occur in the treatment of non-linear devices as circuit elements are interpreted in terms of a graphical physical picture of the processes involved. This picture suggests, in turn, several useful ways of applying the equations in cases where the driving forces are so large that the ordinary power series treatment becomes prohibitively cumbersome. In particular, the application has been made in detail to the calculation of the intermediate-frequency output to be expected from a heterodyne detector having an incoming radio signal and locally generated beating oscillator voltage applied on its grid and a circuit of finite impedance to the intermediate frequency attached to its plate." The two important points in the

application of the method to the heterodyne detector may be summed up in the following statements: (1) The sideband short-circuit current is proportional to the slope of the curve which shows the fundamental component of the output current resulting from the beating oscillator as a function of the grid bias. (2) The internal impedance of the detector is equal to the reciprocal of the slope of the curve which shows the d.c. component of the output current resulting from the beating oscillator as a function of plate potential.

FREQUENCY MODULATION.—John Harmon. (*Wireless World*, 22nd January, 1930, Vol. 26, p. 89.)

Suggesting a cure for the present crowding of the ether by the substitution of frequency modulation for amplitude modulation of the carrier wave. *Cf.* 1929 Abstracts, p. 390, and elsewhere.

THE "WAVE BAND" THEORY OF WIRELESS TRANSMISSION.—J. A. Fleming. (*Nature*, 18th January, 1930, Vol. 125, pp. 92–93.)

The author asserts that neither in wireless telephony nor in television is there any question of various bands of wavelength; there is nothing but a carrier wave of one single frequency which experiences change of amplitude. The question at issue is what change in amplitude in a given carrier wave can be permitted without interfering with simultaneous transmissions at neighbouring frequencies.

SOME POSSIBILITIES OF INTELLIGENCE TRANSMISSION WHEN USING A LIMITED BAND OF FREQUENCIES.—F. E. Terman. (*Proc. Inst. Rad. Eng.*, Jan., 1930, Vol. 18, pp. 167–177.)

The side-band required for an ordinary telegraph relay or printer has been determined for submarine cable telegraphy as slightly under 2.0 times the dot frequency of the signal. 200 wds. per min. by Continental Morse requires 4,762 dot frequency cycles per min., or a side-band of about 131; for a 5-element two-valued code as used in multiplex printing systems, a side-band of only 100 cycles is needed. By employing a synchronous vibrating relay to restore the shape of the received multiplex code signals, it is possible to halve this band, *thus allowing a speed of 200 w.p.m. on a band of only 50 cycles*, with perfectly shaped received signals. "Such a narrow frequency band may seem fantastic to many radio people, but years of submarine cable practice have shown it to be commercially practicable in that service."

Picture transmission requires a side-band of at least 1,800 cycles to transmit 1 sq. in. of 60-line per inch picture per sec. *under the most favourable conditions*; the minimum band is one-half of the number of elements per sec., and this is sufficient only when phase and attenuation distortion is corrected. In television, a good-quality 50-line picture 1 in. square repeated 16 times per sec. requires about 15,000 cycles per sec. when all phase and attenuation distortion has been corrected, and perhaps several times this value with ordinary uncorrected circuits. "The real future of television probably lies in transmission over wires rather than radio," for when radiotelegraphy is eventually worked efficiently as described above, a single television band would displace about 400 telegraph stations working at 200 w.p.m.

In broadcasting, by the continued development of chains and the possibilities of common-frequency Broadcasting through the use of an "interlocking group" system (the combination of a number of common-wave groups each on its own synchronised carrier frequency, these frequencies being adjacent so that the listener will unconsciously tune to the position of clearest reception), "the number of stations that can operate in the present band can be increased many fold." The paper ends by considering the technical problems involved in the effective utilisation of short waves for telegraphy.

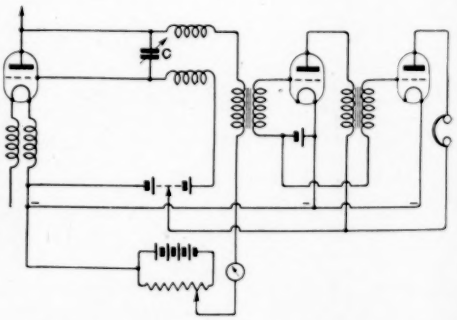
VALVE OSCILLATOR STABILISATION BY SERIES ANODE INDUCTANCE.—Mallett. (*See* under "Measurements and Standards.")

NEON TUBE AS INDICATOR OF CONSTANCY OF FREQUENCY.—McNeely and Ballou. (*See* under "Measurements and Standards.")

RECEPTION.

A NEW TYPE OF RECEIVING SET FOR EXTREMELY [ULTRA-] SHORT WAVES.—S. Uda. (*Tech. Rep. Tôhoku Imp. Univ.*, No. 4, Vol. 8, 1929, pp. 75–82 and Plates.)

For wavelengths 40–80 cms. very satisfactory tuning control is obtained.



For 45 cm. waves, the grid voltage was about + 145 v., plate voltage — 30 v., grid current about 20 ma. The writer mentions, in regard to detection, that as the capacity *C* is gradually increased to catch the signal, a click is generally heard at a certain point *P* and it is just after passing this that the point of most sensitive detection occurs, together with sharp tuning and absence of disturbing noise. As the condenser is thus increased, the plate current suddenly decreases, reaches a minimum, and gradually returns to its original value. This minimum is the point *P*, the "click" being produced by the sudden fall in current.

" It seems likely that at *P* some kind of regenerative amplifying action exists simultaneously with the detecting action." On 45 cms., a range of 5 km. was obtained on modulated c.w. with 10 mA. in the transmitting aerial. Three metre " director " chains were used at each end.

Über die Verstärkung und Gleichrichtung von sehr kurzen elektrischen Wellen (The Amplification and Detection of Ultra-Short Electric Waves).—K. Okabe. (*Zeitschr. f. Hochf. Tech.*, January, 1930, Vol. 35, pp. 3–6.)

If an ultra-short wave generator of the B.-K. type is used as a receiver, under certain conditions a marked amplification occurs in addition to the detector action. The paper describes experiments on the use of a diode, and of a triode in a magnetic field, on these lines; the wavelength was of the order of 50 cm. The work on the diode was dealt with in 1929 Abstracts, p. 633. A high vacuum was ensured by the use of magnesium as getter. Exact symmetry was found to be essential in the construction of the diode. In the case of the triode, cylindrical electrodes were used, and the best results were with a magnetic field of correct value parallel to their axis. For a given value of grid potential and keeping the condenser across the Lecher wires constant, adjustment for good reception was obtained by varying grid current, magnetising current, and anode potential.

Comment les Récepteurs de Radio-Diffusion Évoluent à L'Étranger (The Trend of Design of Broadcast Receivers Abroad).—(*L'Onde Élec.*, Nov./Dec., 1929, Vol. 8, pp. 485–495.)

An article based on papers in *The Wireless World* (20th Nov., 1929), the American *Radio News* (Oct., 1929), and *Proc. A.I.E.E.* (Aug., 1929), and the German *Funk* (6th Sept., 1929).

The Americans appear to be the most advanced as regards mains-feed, this being almost universal. In England its use is increasing rapidly from 17 per cent.; indirect heating is used in 88 per cent. of the mains-fed receivers. Indirect heating is also predominant in Germany (*cf.* Barthélémy, below), where in addition a " large number " of eliminators for receivers using ordinary valves are sold cheaply —for anode supply only—from about 30/-. In Germany, also, two refinements are popular: automatic regulation of filament current by barretters, and automatic cut-off on opening the cabinet.

Screen-grid valves have a " fabulous success " in Great Britain (92 per cent. of all r.f. amplifiers) and in Germany there is hardly a single firm which does not offer a screen-grid model. The U.S.A. seem to be " less advanced " in this direction, but the interest in it is lively and progress will be rapid. Single-knob main adjustment is found on nearly every American receiver, and on half the English. The electrodynamic loud-speaker takes 82 per cent. of the U.S.A. field, and its rivalry has improved the electromagnetic type, of which the balanced armature, four-pole types " give results very nearly as good."

In Germany the " super-het " has lost ground, while in England and America it has almost vanished (4 per cent. and 1 per cent.). Automatic fading compensation is coming into commercial use in America. As regards r.f. amplification, the U.S.A. keep at present to their neutralised triodes, very often having 3 or 4 (even 5 and 6) tuned stages, not counting the detector: the result is that of 190 receivers, not one had less than 5 valves, while 82 per cent. had more than 6. A striking contrast to screen-grid England, where only 3 per cent. had more than 6, 25 per cent. had 4, and 35 per cent. had 3 valves. And to Germany (screen-grid competing with—" who would have believed it ? "—multiple valves with resistance couplings) with apparently about the same percentages. This contrast in the number of valves is partly due, also, to the popularity (52 per cent.) in England (and to a certain extent in Germany) of the single 5-electrode stage for l.f., whereas 85 per cent. of the American receivers use two l.f. stages, the second of which almost always has 2 valves in push-pull or parallel.

The use of reaction in England has diminished from 90 to 75 per cent. in one year: in America it simply does not exist. German " novelties " mentioned are s.g. valves metal-coated externally, the coating being connected to the filament, " forming very simply an excellent electric screening " (*cf.* Kröncke, under " Miscellaneous "); a screened frame aerial; and a " stopping coil " (cartridge type) for insertion in the mains to eliminate parasites.

As regards performance, the writer regrets that he can only quote Hull on the American receivers (1929 Abstracts, pp. 632–633).

Comparison between German and French Receivers.—R. Barthélémy. (*Rev. Franç. de T.S.F.*, Jan., 1930, Vol. 6, pp. 16–17.)

In an article on the Berlin Exhibition of 1929, the writer's comments include the following:—the manufacturing technique gains his unqualified admiration, even allowing for the " special finish " obtaining at Exhibitions. He cites in particular the ganged condensers (" single-knob control is all the rage ") and the complex components in moulded materials. The large expenditure on tools implied by all this is reconciled with comparatively low prices by the fact of the enormous sales: a cost for tools of £4,000 does not matter when spread over the 192,000 receivers of one type made in a year by one firm. In electrical design he considers the French to be ahead of the Germans. Owing to the way the French broadcasting stations are distributed, and the smallness of their power, the French have evolved very selective and very sensitive receivers, particularly the super-heterodyne with frame aerial. A 4-valve German receiver would need a 60 ft. aerial to give signals equal to those obtained on a small frame by a French receiver with the same number of valves.

Mains supply is almost universal in Germany, with indirectly heated valves—the writer astounded the designers by telling them that equally good results could be obtained with directly heated valves: he demonstrated this to one " distinguished technician " and sent him away convinced that the

German trend towards indirectly heated valves was a great mistake.

HUM IN ALL-ELECTRIC RADIO RECEIVERS.—B. F. Miessner. (*Proc. Inst. Rad. Eng.*, Jan., 1930, Vol. 18, pp. 137–166.)

Author's summary :—" This paper presents the results of some further work in the field of all-electric receivers, directed particularly toward the design of receivers and power-supply systems requiring a minimum of apparatus and providing a maximum of hum-eliminating action. It includes the enumeration of the causes of hum, the analysis and measurement of hum, and methods of its elimination."

The methods of elimination dealt with are :—(1) Screening against hum due to induction. (2) Filter and receiver design for minimising hum due to ripple. (3) " Interstage hum bucking "—deliberately increasing the hum in one filter stage and balancing it against the hum in the second filter stage so that they neutralise in the plate circuit of the power valve. (4) Tapped choke filter, considerably increasing the effectiveness of a given amount of filter apparatus. (5) Neutralisation by " hum feed-back "—not in the filter but in the receiver circuit. This may be used with equal advantage in l.f. or r.f. circuits ; with some forms of it an output hum of 50,000 mv. can be reduced to one of about 5 mv. when the circuit constants are carefully adjusted.

THE " VALUNDIA " SYSTEM OF CALIBRATED RECEIVER-ADJUSTMENT. (*QST Franç.*, Nov., 1929, Vol. 10, pp. 56–60.)

A very full illustrated account of the mechanical system mentioned in 1929 Abstracts, p. 151.

THE WAVE-RESONANCE SYSTEM OF TUNING.—Blair and Cohen : J. E. Smith. (*Rad. Engineering*, June, 1929, Vol. 9, pp. 45–46.)

A revival of the stationary wave method of tuning, using the distributed inductance and capacity of a coil. One or more aluminium plates, variable as to distance, serve both as tuning adjustments and as couplings. (*Cf.* Jan. Abstracts, pp. 43 and 44.)

HIGH SELECTIVITY.—W. T. Cocking. (*Wireless World*, 8th January, 1930, Vol. 26, p. 32.)

The design of band-pass filters for the purpose of securing a good compromise between selectivity, quality and magnification. It is shown that several stages can be ganged, thus considerably simplifying receiver control.

SPERRKREIS UND KURZSCHLUSSKREIS (Rejector and Acceptor Circuits).—W. Burstyn. (Summary in *Elektrot. u. Masch : bau*, 20th October, 1929, Vol. 47, pp. 923–924.)

The writer investigates these circuits mathematically, and concludes that the acceptor circuit weakens the desired signals more than the rejector circuit : the latter is therefore to be preferred ; it should not, however, be connected *in* the aerial circuit, but should be coupled tightly to the aerial ; it should be adjusted to the wavelength difference between desired and undesired signals *not* by altering the coupling but by adjusting the transformation ratio by a multi-stud switch which alters the number of turns of the coil. Its capacity should be large and its inductance small : losses, of course, must be reduced as much as possible.

NEW METHOD OF DETECTION USING A.C. VALVES. (*Wireless World*, 8th January, 1930, Vol. 26, p. 45.)

Tests of the Marconi and Osram MHL4 and ML4 valves, using the former as a grid detector. The high-note loss commonly experienced with the usual values of grid condenser and leak is counteracted by the use of modified grid-circuit constants and a plate voltage of 240. It is shown that large inputs can be accepted with a quality superior to that of the anode rectifier.

SIZE VERSUS EFFICIENCY OF SMALL COILS.—A. L. M. Sowerby. (*Wireless World*, 29th January, 1930, Vol. 26, p. 108.)

Tests in the use of compact tuning coils of the order of 2 in. diameter to discover to what extent receiver performance suffers by their use. Laboratory measurements show that while the amplification per stage may be reduced, there is a gain in stability and easy ganging becomes possible.

NOWA METODA ELIMINOWANIA LOKALNEJ RADJOSTACJI (A New Method of Eliminating the Interference from a Local Station).—B. Szapiro. (*Przeglad Radjotech.*, No. 9/10, 1929, Vol. 7, pp. 40–41.)

Investigation of the possibility of eliminating the local signals by the use of a compensating aerial.

W JAKI SPOSÓB ZOSTAL POLEPSZONY ODBIÓR JAPÓNSKIEJ STACJI JND (The Improvement of Reception of the Japanese Station JND—in Poland).—C. Manczarski. (*Przeglad Elektrotech.*, No. 1, Vol 12, 1930, Radio Suppt., pp. 1–7.)

Reception was improved by the combination of a short Beverage aerial and a special arrangement of relays and resistances devised by the writer. This enables the direction of reception to be changed and assures good directional properties.

AMPLIFIKATOR Z AUTOMATYCZNA REGULACJA WZMOCNIENIA (Amplifier with Automatic Amplification Control).—J. Groszkowski and W. Rotkiewicz. (*Przeglad Radjotech.*, Warsaw, No. 19/20, 1929, Vol. 7, pp. 77–81.)

Description and results of tests. The method depends on the displacement of the working point of one amplifying valve along its characteristic of variable slope, in such a way that the slope decreases as the current amplitude increases. The displacement is effected automatically with the help of a kenotron rectifier.

EIN HOCHFREQUENZVERSTÄRKER FÜR VIELE EMPFÄNGER (One H.F. Amplifier for Several Receivers).—M. v. Ardenne. (*Rad., B., F. f. Alle*, Nov., 1929, pp. 494–500.)

A paper on the use of a common aperiodic aerial and a common aperiodic r.f. amplifier for the

simultaneous reception of several broadcasting stations, the amplified signals being passed on to a number of simple "local receivers" (*e.g.*, in a number of flats in the same building) each of which can select whichever station it desires. The article is an extension of the suggestion contained in the writer's paper dealt with in February Abstracts, p. 100.

TUNING CIRCUIT LOSSES.—Sowerby. (*See* under "Properties of Circuits.")

NOTE ON THE STABILITY OF BALANCED HIGH-FREQUENCY AMPLIFIERS.—Nelson. (*See* under "Properties of Circuits.")

AERIALS AND AERIAL SYSTEMS.

RÉFLECTEUR POUR ONDES HERTZIENNES POLARISÉES TRÈS COURTES (Reflectors for Very Short Polarised Hertzian Waves).—A. della Riccia. (*Rev. Gén. de l'Élec.*, 18th Jan., 1930, Vol. 27, pp. 87–90.)

After recalling the properties of cylindrical reflectors with conic directrix, according as this directrix is a hyperbola, a parabola or an ellipse, the writer concentrates on the case of the cylindrical-elliptical reflector. Such a reflector, almost closed, gives no dispersion. Its effective field of emission is represented by a wedge having its apex along the focal line F_2 (nearest the opening) and its limits at the edges of the opening. By bringing these closer, the sector of emission can be reduced as much as is desired. The addition of two plane screens, at the edges of the opening, partly outside and partly inside, is advantageous; they should be aligned with the focal line F_2 or slightly behind this, towards the centre of the ellipse. A cylindrical lens may also be added, to modify the angular opening of the beam. A parallel beam may thus be obtained: the lens need not be too large, since owing to the re-entrant form of the ellipse the opening can be quite narrow. (But to keep down diffraction the opening must be at least 10 times the wavelength.) The oscillator can be situated at either focal line, or there may be an oscillator at each, in opposite phase.

WAVE REFLECTOR AND WAVE DIRECTOR.—S. Uda. (*Tech. Rep. Tôhoku Imp. Univ.*, No. 4, Vol. 8, pp. 63–73.)

Theoretical conclusions as to the action of these directive systems (1928 Abstracts, pp. 103 and 519; 1929, p. 574) are checked by experiment. The directing and reflecting actions of a metallic sheet are discussed, and the absorbing effect of liquid columns of certain electrolytes. With certain concentrations of sulphuric acid, when the length of the liquid column is equal to about $\lambda/2$, the column acts as a good absorber.

THE UNIFORM SHORT WAVE AERIAL.—Marconi Co. (*Marconi Review*, Jan., 1930, pp. 22–27.)

"It is most probable that for nearly all long distance work, *i.e.*, over 2,000 miles, the most useful radiated energy is that which leaves the transmitting aerial system at a zenithal angle of between 5° and 15°. . . . If one adds a series of half-wave aerials vertically so as to oscillate in phase, the zenithal angle of maximum radiation is reduced [from that given by a harmonic aerial] and such a system gives a concentration of energy in directions which are more efficient for short-wave working. . . In beam aerials used prior to the uniform aerial, the radiation from alternate half wavelengths was wholly, or in part, suppressed . . . so that the radiation from the adjacent parts of the aerial should be additive. . . . The uniform aerial, however, has for its principal object the attainment of strongly marked directional qualities without any substantial suppression of radiation. In this aerial, which is long relative to the wavelength employed, the currents are mechanically reversed in direction at alternate half wavelengths, the arrangement being such that the radiation from these sections of the aerial is added to that of the remaining half wavelengths.

"In one form of construction, a vertical aerial is formed with its first or lowest half wavelength as a simple vertical wire. The second half wavelength proceeds for a distance equal to $\lambda/10$ as a prolongation of the first, after which it turns through a right angle and proceeds in a perpendicular direction for $\lambda/20$. It is then bent through a second right angle and extends down through $\lambda/5$, after which it turns through a third right angle and proceeds perpendicularly away from the first half wavelength through a further $\lambda/20$. Finally, it is bent again through a right angle and proceeds upwards through its final $\lambda/10$. The third half wavelength is formed as a vertical prolongation of the last portion of the second. . . .

"By making the length of the wire between centres of adjacent sections of the aerial greater or smaller than half a wavelength, a progressive change of phase between sections may be obtained. Maximum radiation may thus be obtained in directions substantially different from the direction at right angles to the aerial." Results of comparative tests from G5SW are given: these were so definitely in favour of the uniform aerial that the programmes have been sent on this aerial ever since, and the older types are being replaced by the uniform type throughout all the Marconi beam stations. A number of advantages are described: for the same height, the radiation per unit current is very much increased: far less tendency to produce large loops of radiation in undesired directions in the vertical plane: more uniform surface to the wind.

LES ONDES DIRIGÉES ET LEURS APPLICATIONS (Directed Waves and their Applications).—R. Mesny. (*Revue Scientifique*, 12th Oct., 1929.)

Linear networks with transverse radiation (currents in phase); with longitudinal radiation: multiple networks (identical linear systems placed one above the other in the same vertical plane). A formula is given for the total power radiated.

ABGESCHIRMTE RAHMEN (Screened Frame Aerials).—E. Rhein. (*Rad., B., F. f. Alle*, Jan., 1930, pp. 4–13.)

A practical article, illustrated by photographs of

various types of screened frames and sketches of details, along the lines of von Ardenne's papers dealt with in 1929 Abstracts, pp. 450 and 634. The writer deals with the screening of existing frames and the building of screened frames, collapsible and otherwise. He recommends wire screening as a first measure, keeping the more difficult screening with sheet metal in reserve in case the former method is not perfect enough in its results. He particularly recommends these screened frames for mains-driven aperiodic r.f. receivers.

DIE TANTALETTE-ERDANTENNE (The " Tantalette " Earth-Antenna).—Krueger and Wolff. (*Rad., B., F. f. Alle*, Oct., 1929, pp. 454–455.)

This device was referred to rather ironically in the above journal's review of the Berlin Show of 1928. The present writers, on the other hand, have found it invaluable for reception in Egypt; it gave good loud-speaker reproduction even from the smallest European stations on the worst evenings, when high aerials and frames alike gave very inferior results owing to the bad atmospherics.

VALVES AND THERMIONICS.

THE EFFECT OF LIGHT ON THE ELECTRON EMISSION FROM OXIDE-COATED FILAMENTS.—K. Newbury. (*Phys. Review*, 1st Dec., 1929, Vol. 34, pp. 1418–1425.)

The increase in emission when light is focused on these filaments was studied as a function of applied potential, filament temperature, and wavelength of the light. All the results obtained experimentally find an adequate explanation if it be assumed that the normal photoelectric emission from the oxide coating so modifies the distribution of its intrinsic surface field as to alter the effect of the externally applied field on the work function of the surface.

THE EFFECT OF LIGHT ON THE ELECTRON EMISSION FROM CERIUM DIOXIDE.—C. E. Berger. (*See* under " Phototelegraphy.")

ACTION DE LA LUMIÈRE SUR LES PHÉNOMÈNES THERMIONIQUES (Action of Light on Thermionic Phenomena).—R. Deaglio. (*Comptes Rendus*, 3rd Feb., 1930, Vol. 190, pp. 299–300.)

Tests made with a diode specially designed to give a true thermionic emission led to the following results:—far away from saturation, the increase of thermionic current due to illumination was of the order of 10^{-8} A., of which only one hundredth part could be due to increase of filament temperature produced by the light; the effect therefore was almost wholly photoelectric. The shortest wavelength in the light was 3,000 A.U., and the photoelectric current produced by the light on the *cold* filament was too small to be noticed. With saturation, the light produces an increase of current, but no conclusion as to a photoelectric effect can be drawn here, since under these conditions the increase of temperature produced by the illumination gives rise to an increase of current of the same order as that observed.

THE EFFECT OF INTENSE ELECTRIC FIELDS ON THE PHOTOELECTRIC BEHAVIOUR OF ALKALI FILMS ON TUNGSTEN.—Lawrence and Linford. (*See* under " Phototelegraphy.")

GENERAL CONSIDERATIONS ON THE EMISSION OF ELECTRONS FROM CONDUCTORS UNDER INTENSE FIELDS.—P. W. Bridgman. (*Phys. Review*, 1st Dec., 1929, Vol. 34, pp. 1411–1417.)

Author's abstract:—With the classical picture of the electron, a thermodynamic discussion is given of the current drawn from metals by intense fields, using the Volta difference of potential between two metals to produce the intense field. It is found that the order of the metals arranged according to the magnitude of their field currents is the same as their order arranged according to their Volta potential differences. It is also found that the density of the electron atmosphere in equilibrium with the metal is the same with a given field whether the direction of the field is such as to drive the electrons towards the metal or to pull them away from it. The modifications demanded in these conclusions by the wave-mechanics picture of the electron are briefly discussed; it seems probable that the first result will stand but that the second would have to be much modified, the precise method of modification not being now evident. In connection with the present wave-mechanics picture, it is suggested that the potential discontinuity imagined to be encountered by all of the electrons in leaving the metal may be statistical in character. Expressions are given for the change in heat of evaporation of electrons and in the photoelectric threshold efficiency produced by intense fields in terms of a slight change of Volta difference. Attention is called to a temperature correction which will have the effect of making the field current not absolutely independent of temperature at low temperatures, as has been supposed.

THERMIONIC VALVE WITH COMMON SUPPLY FOR CATHODE AND ANODE.—(French Pat. 664744, Thomson-Houston, pub. 6th September, 1929.)

The valve contains a hollow cathode, an internal heater for this, and a thermostatic strip and contact. When the valve is cold, current from the single battery passes through a resistance (connecting thermostatic strip with anode) to the heater, then to the cathode, and back to the battery. When a certain temperature is reached the strip breaks contact and the cathode becomes disconnected from the battery, which serves now only as anode battery. The heater is now positive to the cathode, and the consequent electronic bombardment keeps it red hot.

WIRKEN ATMOSPHÄRISCHE ENTLADUNGEN SCHÄDIGEND AUF DIE RÖHREN EINES EMPFANGSGERÄTS? (Do Atmospheric Discharges Damage Receiving Valves?).—E. Sauter. (*Rad. B., F. f. Alle*, Feb., 1930, p. 69.)

The writer has for several years noticed that valve filaments lose their emitting properties more rapidly in seasons when atmospherics are frequent than

in quiet periods. He has now found that a corresponding deterioration takes place in a crystal receiver.

VACUUM TUBE DESIGN—AND PRODUCTION.—P. G. Weiller. (*Rad. Engineering*, Sept., 1929, Vol. 9, pp. 34–36.)

"The quality requirements of vacuum tubes for use in broadcast receivers." Part III, in the November issue, deals with the methods of seasoning valves, and some practical equipment.

RECHERCHES ET ESSAIS SUR LES LAMPES DE T.S.F. (Researches and Tests on Wireless Valves).—A. Kiriloff. (*QST Franç.*, Oct., 1929, Vol. 10, pp. 51–63.)

Among the many valves briefly dealt with in the present instalment (see earlier Abstracts) are:—a special valve for television, in which the grid is coated with a photo-sensitive material: voltage-regulating argon or neon-filled rod-to-spiral tubes (Type Métal); power valves up to 200 kw., including a 6 kw. Holweck in which the parts can be replaced.

PORCELAIN POWER VALVES.—Metropolitan-Vickers Co. (*Engineer*, 10th Jan., 1930, Vol. 149, pp. 37–38.)

"At the present time an oscillator valve of 20 kw. input at 12,000 v., which generates power at 600 m., is in use. It was felt that glass was too fragile to be satisfactory in large-size valves. Experiments with unglazed and glazed porcelain have, however, proved satisfactory, and as these valves can be made up to ¼ ton in weight, a new field is being opened up."

THE CONTROL GRID GLOW TUBE ["Grid-Glow" Tube].—W. E. Bonham. (*Rad. Engineering*, November, 1929, Vol. 9, pp. 30–33.)

Technical data on the properties and characteristics of these relay tubes.

ON THE DISTRIBUTION OF SPACE CHARGE BETWEEN A PLANE HOT CATHODE AND A PARALLEL ANODE.—H. Rakshit. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 80–87.)

A calculation of the distribution of electron density between a plane-heated cathode and a parallel anode when a thermionic current flows between the two, with numerical results for a few typical cases. When a current flows, the electron density diminishes immediately near the hot surface but increases at a greater distance from it.

THE NEUTRALIZATION OF SPACE CHARGE BY POSITIVE IONS IN CÆSIUM VAPOR.—V. E. Whitman. (*Bur. of Stds. Journ. of Res.*, Jan., 1930, Vol. 4, pp. 157–167.)

The positive ions were formed by the photo-electric ionisation of cæsium vapour. The change in current due to the illumination was measured as a function of such controllable variables as pressure, light intensity, anode voltage, and cathode emission. An empirical relation between change in anode current and illumination

$$\left[\frac{I}{\triangle i} = K_3(i + \triangle i)\right]$$

is given which may be made to fit the observations by the choice of the constant K_3.

TUNGSTEN ORE IN S. CHINA.—(*Engineer*, 10th January, 1930, Vol. 149, p. 47.)

VACUUM DETERMINATION BY THE MEASUREMENT OF POTENTIAL FALL OF THE IONIC CURRENT.—W. Rotkiewicz. (*Przeglad Radjotech.*, No. 9/10, 1929, Vol. 7, pp. 39–40.)

By measuring the voltage drop in a known resistance through which the grid current (of the order of 10^{-8} A.) passes, the writer determines the degree of evacuation, using a voltmeter and milliammeter of only ordinary sensitivity.

DIRECTIONAL WIRELESS.

LE GUIDAGE PAR ONDES DIRIGÉES OU RADIOROUTES —PROCÉDÉ LOTH (Guiding by Directed Rays or "Radio-Routes"—Loth Method).—. Bourgonnier: W. Loth. (*L'Onde Élec.*, Nov./Dec., 1929, Vol. 8, pp. 469–484.)

A long paper on Loth's new substitute for the "leader cable," dealt with in February Abstracts, p. 104 (first abstract). All the first part concerns general principles and applies equally to the use of ultra-sonic, luminous, infra-red or Hertzian waves. The last part deals with the special case of radio beams, which "give perhaps the most interesting results owing to their long range and their sufficiently good transmission in all weathers": and since reception is entirely non-directional—being on an open aerial—there are no d.f. errors in reception: if there are any variations in transmission according to time of day or seasons, they can be corrected by a suitable changing of the law of rotation of the two beacons. Moreover, reception is not complicated by compass errors, charting errors, etc., etc.

The whole secret of the method depends on the co-ordination of the rotation of the two beacons, so that their beams intercept along the desired course. This is accomplished either by specially shaped cams or by moving paper bands perforated (like a pianola roll) so as to give the correct electric impulses to vary the speed of rotation at various points of each successive turn. The comparatively poor directivity of radio waves is "almost completely palliated" by the use, at the receiver, of the Marrec filter, with its extreme selectivity and its limiting effect; this filter also plays an important part so far as aircraft is concerned, in eliminating interference—especially from the magnetos. By a suitable arrangement of signals, the number of kilometres already travelled or the number remaining, and for aircraft the height at which it should fly, can be communicated in addition.

Tests already carried out both with short radio waves (apparently of the order of 10 m.) and with light waves have shown that the principle is absolutely correct and have given most satisfactory results.

NOTE ON RANGE-FINDING.—F. Morley and H. A. Robinson. (*Proc. Nat. Acad. Sci.*, Jan., 1930, Vol. 16, pp. 74–77.)

(1) The Problem on a Plane :—the location of an object, such as a gun P by timing the sound or other vibration of known velocity at different stations P_i ($i = 1, 2, \ldots\ldots n$). (2) Coördinates of the Gun. (3) Elimination of Temperature. (4) The Problem on a Space. (5) The Problem on a Sphere :—the following relations, for four observations, are arrived at, a_i and b_i being the longitude and co-latitude of the point P_i, a and b those of the source, while d_i is a known distance given by the time for a fixed longitude recorded at P_i multiplied by the known velocity :—$\cot a \mid \cos b_i, \sin b_i \cos a_i, \cos d_i, \sin d_i \mid + \mid \cos b_i, \sin b_i \sin a_i, \cos d_i, \sin d_i \mid = 0$, and $\cot b \mid \cos b_i, \sin b_i \cos a_i, \cos d_i, \sin d_i \mid + \cos a \mid \sin b_i \cos a_i, \sin b_i \sin a_i, \cos d_i \sin d_i \mid = 0$, giving the longitude and co-latitude of the source.

THE CALIBRATION AND CORRECTION OF NAVAL DIRECTION FINDERS.—N. Lea. (*Marconi Review*, Dec., 1929, pp. 18–21.)

From Mesny's equation $\tan \phi = A \tan \theta$ error/dial-reading curves can be derived of various maximum amplitudes. With a "family" of such curves it is a simple matter to find by test which curve best fits a particular ship, and a common correcting method (which must obey the same law as the errors) can then be applied and adjusted. "The Marconi method, of shunting one of the B.T. loops by means of a choke, does follow the tangent law."

FUNK UND FLUG (Wireless and Aircraft).—H. Orlovius. (*Luftfahrt*, 22nd Oct., 1929, Vol. 33, pp. 291–293.)

This short survey of recent development in Germany ends with a recommendation of the use of picture telegraphy as an aid to pilots. It shows two examples of charts received in an aeroplane with the "comparatively small and light Fultograph receiver"—one of these is a weather chart showing the advance of a line squall, the other is an aerodrome map showing a flooded portion of the landing ground.

ACOUSTICS AND AUDIO-FREQUENCIES.

THE MEASUREMENT OF MECHANICAL IMPEDANCE.—E. Mallett and R. C. G. Williams. (*Elec. Review*, 14th Feb., 1930, Vol. 106, p. 294 ; *E.W. & W.E.*, March, 1930, pp. 144–145.)

Extract from an I.E.E. (Wireless Section) paper. The device under test (*e.g.*, a gramophone pick-up) is driven by one prong of an electrically driven tuning fork, and the other prong is loaded till balance is restored, as indicated by absence of vibration of the fork support : the load required is the mechanical impedance sought for. An improvement depends upon the experimentally determined fact "that mechanical resistance out-of-balance does not appreciably affect the support vibration. If the prongs are balanced for mass, the total resistance can be found from a decay-factor determination, or by a single measurement of amplitude with a known current, and the resistance of the device estimated."

A NEW GRAMOPHONE PICK-UP.—G. W. Sutton. (*Elec. Review*, 14th Feb., 1930, Vol. 106, pp. 294–295 ; *E.W. & W.E.*, March, 1930, p. 145.)

Extract from an I.E.E. (Wireless Section) paper describing the results of an experimental investigation into the performance of certain types of commercial pick-ups, "the majority of which leave much to be desired." The investigations have led to a new design being evolved. To fit in with the present tendency in broadcast receiver design, the output should be of the order of 0.15 volt per mm. per cycle per second (measured from the positive to the negative peaks of the amplitude of the needle-point displacement). Considerations of voltage output and cost of production led the writer to conclude that the moving-iron e.m. type was the only choice, and he adopted the balanced armature pattern.

Preliminary tests on commercial types of pick-up brought out the following points (1) the existence in every case of one or more resonant points in the voltage characteristic, causing distortion and, presumably, damage to the record. (2) A tendency, with some pick-ups, for the needle to jump out of the groove at frequencies below about 100 p.p.s. In *all* cases, distinct vibration of tone-arm or lever could be felt at low frequencies. (3) A comparatively poor voltage output at 5,000, 4,000 and sometimes even 3,000 p.p.s., leading to lack of "brilliance" in reproduction. The writer describes the steps taken in his design to avoid these three defects. The position on the frequency scale of the principal resonance is governed by the inertia of the armature and the sum of the stiffness of the armature suspension and of the needle. In a well-designed instrument the former stiffness will be small compared with the latter (of the order of 1 : 10), so that the latter is the governing factor ; the only means, therefore, of raising the principal resonance to a high figure is to reduce the armature inertia. The commercial pick-up's inertia constant is much too high (1.5 gm. cm.^{2}). The writer's armature was therefore designed to have a value not more than 0.5 gm. cm.^{2} ; it was made hollow, and suspended at its mid-point (mounted on a mica disc, whose stiffness in the plane parallel to the pole faces was increased to nearly twice that in the plane of normal vibration by means of two elliptical washers). The value of the suspension control constant was 13.8×10^6 dyne cm. per radian, which is little more than half the value for a commercial instrument tested. The pick-up was connected very rigidly to a massive and rigid supporting lever, so adjusted about its pivots that the bearing pressure on the needle was about 100 gms. There is a space above the mica disc which may be filled with oil of suitable viscosity to provide additional damping.

THE PROBLEM OF DISTORTION IN SOUND FILM REPRODUCTION.—C. O. Browne. (*E.W. & W.E.*, Feb., 1930, Vol. 7, pp. 71–77.)

Author's summary :—The frequency characteristics of a recording and reproducing sound film system are discussed independently with a view to producing a level combined frequency response. At the same time, the reproduction should be

tolerably free from surface noise. Various recorders, and the methods by which their frequency responses can be brought into line with that of the reproducer, are described. Correction can also be made for recording and reproducing slit attenuation. A recording system producing a twin wave track record of the variable width type is described in some detail, and the essential points of a variable density recording are observed.

AUDIO-FREQUENCY TRANSFORMERS: VOLTAGE RATIO CHARACTERISTICS DETERMINED BY THE LOW-VOLTAGE CATHODE RAY OSCILLOGRAPH.—P. Klev and D. W. Shirley. (*Journ. Am. I.E.E.*, December, 1929, Vol. 48, pp. 907–911.)

"This newly developed method is accurate and simple in operation, and gives the actual characteristics of the transformer for all frequencies and d.c. components." The usual method, with a triode, gives results which are a combination of the characteristics of transformer and triode, and is therefore not entirely satisfactory. With the present method, precautions must be taken to eliminate stray fields.

NOTE SUR LES TRANSFORMATEURS TÉLÉPHONIQUES (Note on Telephonic Transformers).—P. Chavasse. (*Bull.d.l.Soc.Franç.d.Élec.*, Nov., 1929, Vol. 9, pp. 1190–1212.)

THE DYNAMICAL THEORY OF RESONATORS.—E. T. Hanson. (*Proc. Phys. Soc.*, 15th Feb., 1930, Vol. 42, Part 2, pp. 43–57.)

APPLICATION DES PHÉNOMÈNES ÉLECTROCAPILLAIRES À L'ACOUSTIQUE: INTERPRÉTATION DE LA COUCHE DOUBLE (Application of Electro-capillary Phenomena to Acoustics: Double Layer Interpretation).—F. Carbenay: M. Latour. (*Rev. Gén. de l'Élec.*, 2nd November, 1929, Vol. 26, pp. 693–696.)

Latour's electro-capillary microphone is well known (1928 Abstracts, p. 289). The present paper investigates the mathematical theory of this, and of its related capillary receivers and detectors. As one result, the specification of a transformer for coupling the microphone to a valve can be calculated.

INTERFERENZEN DURCH KOLBENMEMBRANEN VON BESONDERER FORM (Interference from Piston Diaphragms of Special Form).—H. Stenzel. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 567–569.)

The influence of interference on the frequency curves of diaphragms is discussed by means of three examples. In particular, it is shown that the theoretically calculated frequency characteristic of the cone loud-speaker correctly represents the important points of the practically measured curve.

AN ARTIFICIAL EAR.—W. West. (*P.O. Elec. Eng. Journ.*, January, 1930, Vol. 22, pp. 260–263.)

Apparatus complying with the specification that its acoustical impedance shall lie within the range of normal variations obtained for real ears; it consists of a coupling device associated with a condenser transmitter whose frequency characteristic is not seriously affected thereby. Possibilities are indicated for the use of this apparatus for replacing real ears in transmission measurements.

PHYSICAL PRINCIPLES OF SOUND REPRODUCTION.—K. W. Wagner. (*A.E.G. Mitt.*, September, 1929, pp. 567–575.)

In the course of this paper the writer points out that while vowel sounds are generally transmitted well by broadcasting stations, the same cannot be said of the consonants—particularly the sibilants, which possess numerous harmonics between 5 and 10 thousand p.p.s. It is for this reason, he states, that the German transmitters are designed so as to deal with sounds within these limits, whereas other transmitters—French and English—stop short at 5,000 p.p.s.

DIE SCHALLAUFNAHME DURCH DAS ÄUSSERE OHR (Sound Reception by the External Ear).—J. Tröger. (*Phys. Zeit.*, January, 1930, Vol. 31, pp. 26–47.)

Measurements of the dependency of the mechanical behaviour of the ear-drum on the frequency of the received sound are described, the method used being an acoustical analogue of the Lecher wire system used in high-frequency electrical measurements. A mathematical theory of the method is developed.

The measurements show that the ear-drum is to be regarded as a complex resistance of elastic type which is very large for low frequencies, reaches a minimum value for 800 cycles/sec., and above this frequency shows damped resonances.

BEITRAG ZUR FRAGE DER STIMMRICHTWIRKUNG (Contribution to the Question of the Directional Effect of the Voice).—F. Trendelenburg. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 558–563.)

An experimental investigation. The measurements were made on three sounds—the *U* (200–400 cycles), *I* (3300–3600), and *S* (up to 6000). The higher frequencies were strongly directed in their radiation: the trumpet effect of the mouth causes the directivity to be greater than is theoretically deduced from consideration of the head as a spherical screen.

THE IMPROVEMENT OF THE ACOUSTICS OF AN AUDITORIUM.—.—. Herkt. (*Deutsche Bauzeit.*, 24th September, 1929.)

AN AID FOR THE DEAF.—(*Wireless World*, 15th January, 1930, Vol. 26, p. 71.)

Describing the "Radiophone," developed by Dr. Gustav Eichhorn, of Zurich. The device consists of an electrostatic earpiece, the functioning of which suggests that the flesh surrounding the ear is forced, by an electrostatic effect, to set up oscillations which are not transferred to the skin of the ear-drum, but direct to the organs of hearing. (*Cf.* 1929 Abstracts, p. 217.)

THE ANALYSIS AND MEASUREMENT OF THE NOISE EMITTED BY MACHINERY.—B. A. G. Churcher and A. J. King. (*Journ. I.E.E.*, January, 1930, Vol. 68, pp. 97–131.)

"The paper deals with part of a comprehensive investigation which is being carried out by a manufacturer of electrical plant on the noise emitted by machinery and other apparatus, a subject of great present and future importance." There is a long and interesting section on methods of calibration for the microphone. In the subsequent discussion Mallett remarks that it is interesting to note that the moving coil microphone (used instead of the usual condenser type) proved so successful. *Cf.* Spooner and Foltz, 1929 Abstracts, p. 638.

PHOTOTELEGRAPHY AND TELEVISION.

CATHODE-RAY TELEVISION RECEIVER DEVELOPED. —V. Zworykin. (*Scient. American*, February, 1930, Volume 86, p. 147.)

The pictures formed by this receiver are 4×5 inches in size: "they can be made larger or brighter by increasing the voltage used in the receiver." A reflecting mirror allows the picture to be observed by a number of spectators. "Synchronisation is accomplished easily even when using a single radio channel." "Using a fluorescent screen, the persistence of the eye's vision is aided and it is possible to reduce the number of pictures shown each second without noticeable flickering. This in turn allows a greater number of scanning lines and results in the picture being produced in greater detail without increasing the width of the radio channel." The apparatus is now being used in experimental form in the Westinghouse research laboratories, and a number of similar receivers are being constructed.

IMPROVED NEON TUBE FOR TELEVISION. (*Rad., B., F. f. Alle*, Jan., 1930, p. 30.)

The new Geffcken-Richter neon tube has an anode shaped like a picture-frame, placed a few millimetres away from the flat cathode and parallel to the edges of this. This frame design gives sharp edges to the field of glow (since the anode screens the edges of the cathode) which makes synchronisation easier. It also gives a more uniform and simultaneous distribution of light. There is an auxiliary anode behind the cathode, connected through an 0.1 megohm resistance to the positive pole of the anode battery. This gives a continuous faint glow discharge from its edges to the cathode, too faint to interfere with the television (and, moreover, screened by the frame-anode) but keeping the gas continually ionised. The tube is filled with a mixture of helium and neon with a slight addition of mercury vapour, and gives a bright red light.

TELEVISION, SOME SUGGESTED SCHEMES.—E. G. Lewin. (*Television*, Jan., 1930, Vol. 2, pp. 554–561.)

A lecture before the Television Society. The suggested schemes include those of Ritcheouloff (Feb. Abstracts, p. 108); Whitten (scanning-mirror mechanically oscillated by piezoelectric crystals); von Bronk (a multiplicity of Kerr cells for analysing and synthesising the image: and the use of piezoelectric quartz plates in place of the Kerr cells, making use of the polarisation rotating powers of the quartz); Zworykin (rotating prisms giving a spiral scanning pencil—*cf.* Westinghouse pat., Feb. Abstracts, p. 109); and Mohr, who analyses mathematically the distortion of the image produced by apertures of finite size in the scanning disc, and inserts filter circuits in the transmitter and receiver to compensate for that distortion.

ARTICLES ON TELEVISION: HISTORICAL: THE BUILDING OF AN EXPERIMENTAL APPARATUS USING A SELENIUM CELL: ON THE ORGANISATION OF TELEVISION TRANSMISSION—AN APPEAL AND A WARNING TO THE BROADCASTING AUTHORITIES. (*Rad., B., F. f. Alle*, Jan., 1930, pp. 20–30.)

TELEVISION AT THE BERLIN RADIO EXHIBITION. (*Television*, October, 1929, Vol. 2, pp. 379–389.)

A fully illustrated description of the various systems exhibited. An interesting point was mentioned by Schröter as one reason for preferring vertical scanning to the horizontal scanning prescribed for Germany:—if the receiving motor has any tendency to hunt, the resulting movement is to and fro horizontally; in the case of vertical scanning the movement is vertical. Through long usage, the human eye is much more sensitive to horizontal movement; moreover, it subconsciously compensates for vertical ones because in walking the head moves slightly up and down.

TELEVISION IN COLORS BY A BEAM SCANNING METHOD.—H. E. Ives and A. L. Johnsrud. (*Journ. Opt. Soc. Am.*, Jan., 1930, Vol. 20, pp. 11–22.)

An illustrated description of the system and apparatus referred to in 1929 Abstracts, p. 580. "The colored images produced . . . are quite striking in appearance, in spite of the rather low brightness and small size which are characteristic of the present stage of development. The addition of color contributes notably to the naturalness of the images, and constitutes, from a technical standpoint, a considerable advance. It is obvious, however, from the discussion which has been given of the problems encountered, that television in color is intrinsically far more complicated and costly than television in monochrome and hence is likely to wait much longer for practical utilization."

SYNCHRONISATION IN TELEVISION.—T. S. Roberts. (*Television*, October, 1929, Vol. 2, pp. 395–398.)

Description of the Baird relay synchroniser and the more recently adopted "toothed wheel" arrangement.

N.E. PICTURE-TELEGRAPHY SYSTEM.—Y. Niwa: M. Kobayashi. (*Engineering*, 20th Dec., 1929, Vol. 128, p. 823.)

Short description of the Nippon Electric Co.'s system. Nothing new is here indicated.

THE USE OF FULTOGRAPH RECEIVERS IN AIRCRAFT. —Orlovius. (*See* under "Directional Wireless.")

DER GEGENWÄRTIGE STAND DER BILDTELEGRAPHIE: 8. — SIEMENS-KAROLUS, FÜR PRESSÜBERTRAGUNGEN (The Present Position of Picture Telegraphy: 8.—Siemens-Karolus Press Service System).—F. Noack. (*Rad., B., F. f. Alle*, Nov., 1929, pp. 505–510.)

THE EFFECT OF INTENSE ELECTRIC FIELDS ON THE PHOTOELECTRIC BEHAVIOUR OF ALKALI FILMS ON TUNGSTEN.—E. O. Lawrence and L. B. Linford. (*Phys. Review*, 1st Dec., 1929, Vol. 34, p. 1492.)

The writers' initial experiments on the photoelectric behaviour of metal surfaces in strong fields show, as the work of Becker and Mueller suggested, that the photoelectric threshold of films of the alkalies are shifted by large amounts towards the red by application of quite ordinary electric fields. Thus a field of 69,000 v./cm. at a surface of potassium on oxygen on tungsten extends the threshold in the infra-red from 8,800 to 10,600 A.U. (corresponding to a reduction of work function of the surface of about 0.23 v.). It appears that not only thresholds but the whole spectral sensitivity of the surfaces over the whole range investigated are shifted towards the red approximately to this extent.

Presumably larger reductions of the photoelectric work functions could be accomplished by the application of more intense fields if it were not for the setting-in of field currents (auto-electronic emission—10^{-12} A.—was found to begin at fields of the above magnitude).

ACTION DE LA LUMIÈRE SUR LES PHÉNOMÈNES THERMIONIQUES (Action of Light on Thermionic Phenomena).—R. Deaglio. (*See* under "Valves and Thermionics.")

THE KERR ELECTROSTATIC EFFECT.—E. F. Kingsbury. (*Review of Scient. Instr.*, Jan., 1930, Vol. 1, New Series, pp. 22–32.)

A mathematical treatment of the subject. Curves show a comparison of the transmitted light, as calculated by the formulæ obtained, with that obtained by experiment. The effect of impurities in the nitrobenzol is seen. It is shown that while the practical use of the Kerr cell has been confined to the region up to the first maximum, the characteristic more closely approaches linearity on the portion between the first maximum and the second minimum, and even more so up to the second maximum, so that these regions would be better for operating the cell, if it were not for the colour separation and the inadvisability of applying very high electric fields.

Another set of curves shows the theoretical transmission of the system as a function of the voltage, for different polarising angles—a plot of the equation

$$I = a^2\{\cos^2(i - \phi) - \sin 2i \sin 2\phi \sin^2\delta/2\}.$$

There is an increasing approximation to linearity as i is decreased, until at zero the cell no longer functions and the transmission is due entirely to the polariser-analyser position. Changing i further to negative values inverts the corresponding positive curve and the transmission will then decrease as the voltage is increased to 730. If $i = -\pi/4$ and white light is used, the cell cannot be expected to have zero transmission at 730, because of the spectral separation.

ÜBER DEN KERREFFEKT AN GASEN UND DÄMPFEN (The Kerr Effect in Gases and Vapours).—H. A. Stuart. (*Zeitschr. f. Phys.*, 18th Dec., 1929, Vol. 59, No. 1/2, pp. 13–34.)

THE EFFECT OF LIGHT ON THE ELECTRON EMISSION FROM CERIUM DIOXIDE.—C. E. Berger. (*Phys. Review*, 15th Dec., 1929, Vol. 34, pp. 1566–1574.)

Author's abstract:—Ultra-violet light was found to increase the electron emission from hot filaments coated with cerium dioxide, thorium oxide, calcium oxide or calcium iodide. In the case of cerium dioxide on platinum at about 1,000° C., the photoemission varied linearly with the intensity of the light; wavelengths above 3000 A.U. were not effective. Air, hydrogen or oxygen in small amounts caused a decrease in the photo-emission. The saturation photo-currents showed distinct increase with increase in temperature. Sufficient evidence was not obtained to decide whether this constitutes a variation of the true photoelectric effect with temperature, or whether some other cause operates—such as change of surface by bombardment.

THE EFFECT OF LIGHT ON THE ELECTRON EMISSION FROM OXIDE-COATED FILAMENTS.—K. Newbury. (*See* under "Valves and Thermionics.")

THE ACTINO-DIELECTRIC EFFECT.—H. Wolfson. (*Television*, October, 1929, Vol. 2, pp. 417–419.)

This is the name first given by Lenard and Saeland to the effect, analogous to the photoelectric effect in metals, of light on certain non-metals. The present article is a short survey of the results of these workers and of Goldmann and Kalandyk (sulphur), Ries (selenium), Oeder, Schmidt and Lenard (the actino-dielectric effect—no connection with phosphorescence) and Pauli (a.-d. effect and fluorescence).

SPECIAL STYLOGRAPHIC PEN FOR FACSIMILE TELEGRAPHY. (French Pat. 668527, Belin, pub. 4th Nov., 1929.)

The body of the pen holds resin (powdered or granulated) which is melted electrically and flowing out like ink forms a record which is in relief.

PROTECTION DU SYNCHRONISME SUR LES TRANSMISSIONS RADIOTELEGRAPHIQUES BAUDOT-VERDAN (Maintenance of Synchronisation in the Radiotelegraphic Transmissions of the Baudot-Verdan System). — Ch. Bonnin. (*Bull. d.l. Soc. Franç. d. Élec.*, September, 1929, Vol. 9, pp. 974–981.)

MEASUREMENTS AND STANDARDS.

EFFECT OF SMALL CHANGES IN TEMPERATURE ON THE PROPERTIES OF BODIES.—M. D. Hersey. (*Bur. of Stds. Journ. of Res.*, Jan., 1930, Vol. 4, pp. 137–156.)

Author's abstract:—When it is found necessary to determine the effect of small departures from normal temperature upon some property of a body or system of bodies, such as the stiffness of a steel spring, the vibration frequency of a tuning fork, or the accuracy of an instrument, it is usually done either (*a*) by a detailed computation, or (*b*) by a direct experiment in which the temperature is actually varied.

After reviewing and illustrating the usual methods of solution a general mathematical treatment of the problem is given, from which two additional methods are derived that can sometimes be usefully applied: (*a*) A simple calculation, made possible by the theory of dimensions, which does not require any detailed formula for the property in question; and (*b*) a combined theoretical and experimental solution, in which the experimental factors have been reduced to a minimum and can be determined without varying the temperature of the body itself, provided the thermal properties of the component materials are known.

Finally, it is pointed out that the same treatment can be extended to any other condition analogous to temperature, such as hydrostatic pressure.

VALVE OSCILLATOR STABILISATION.—E. Mallett: C. R. Urwin and W. J. E. Tobin. (*Elec. Review*, 14th Feb., 1930, Vol. 106, pp. 295–296: *E.W. & W.E.*, March, 1930, pp. 145–146.)

Short summary of an I.E.E. (Wireless Section) paper, describing how "the addition of a series inductance of suitable value to the anode circuit of a valve oscillator results in the frequency of the oscillations generated being independent of fluctuations in the valve constants" (? working conditions). The effect is to bring the grid and anode voltages into exact phase opposition, thus making the frequency of the maintained oscillations the same as that of the free undamped ones of the oscillatory circuit. The correct value depends on the frequency; the stray capacities may be such that the value required is negative, *i.e.*, capacity must be added; or it may just happen that the circuit is already stabilised at the particular frequency. Experiments are being continued to ascertain whether such a triode circuit can take the place of the tuning fork or quartz crystal. A constant-temperature chamber would be required, as it is for these latter oscillators.

NEON TUBE AS INDICATOR OF CONSTANCY OF FREQUENCY IN AN OSCILLATOR.—J. K. McNeely and R. P. Ballou. (*Elec. World*, 11th Jan., 1930, pp. 101–102.)

In the course of an article on the operation of neon tubes, the writers mention some experiments on a 1½ ft. tube excited by r.f. currents (1,306–4,535 kc.). Various patterns of "luminescent sections" (striæ, "bubbles," and columns) were formed: "with exactly the right capacity the bubbles . . . were stationary. With a slight change in capacity, they had a continual motion across the tube, towards the negative end as the capacity and wavelength were decreased and towards the positive end if the capacity and wavelength were increased. The adjustment was very critical, and this suggests a method of determining with extreme accuracy whether or not a laboratory oscillator . . . is remaining constant. A slight motion of the hand 2 ft. from the oscillator was sufficient to cause or stop the motion of these bubbles, a change in capacity far too small to be detected by an accurate wavemeter." *Cf.* Wood, under "Gen. Phys. Articles."

ÜBER EINE DIREKTE METHODE ZUR MESSUNG VON KLEINEN DÄMPFUNGEN BEI PIEZOKRISTALL-RESONATOREN (A Direct Method of Measuring Small Decrements in Piezoelectric Crystal Resonators).—S. Chaikin. (*Zeitschr. f. Hochf. Tech.*, January, 1930, Vol. 35, pp. 6–9.)

The usual Bjerknes' method not only presents theoretical difficulties when applied to piezoelectric resonators (since it depends on the oscillations following a logarithmic law) but has a number of practical objections—*e.g.*, the slightest frequency variation upsets the shape of the resonance curve, the liability of reaction of the crystal oscillator on the valve generator, etc. The writer's direct method is free from all these objections. It is as follows:—the piezoelectric oscillator is set into oscillation by a valve generator. At a certain instant (t_0) the generator action is cut off and the oscillator is allowed to oscillate freely. After a definite interval (at the instant t_1) an electrical circuit, to which a detector and ballistic galvanometer are coupled, is connected to the crystal electrodes.

If this detector follows the square law the galvanometer deflections are proportional to the value $\int_{t_1}^{t=\infty} i^2 dt$, where i is the current produced in the electrical circuit by the crystal oscillations. Keeping starting conditions the same and taking readings for various values of t_1, a curve is obtained from which the damping law can be derived, without any assumption as to the linearity of the oscillation equations. The method can be applied to other resonators—*e.g.*, magnetostrictive.

Measurements by this method show that in quartz resonators the external effects (mechanical friction and acoustic radiation) cause heavy damping. By eliminating these factors the damping can be greatly decreased. "The damping reaction of the electrical circuit must also cause small damping, and if this effect were eliminated the decrement might perhaps be still further reduced."

IS IT POSSIBLE TO DETERMINE THE PIEZOELECTRIC CONSTANT AT HIGH TEMPERATURE BY THE STATICAL METHOD?—Schulwas-Sorokina. (*Phys. Review*, 1st December, 1929, Vol. 34, pp. 1448–1450.)

It is suggested that the measurements of the variation with temperature of the piezoelectric effect in quartz and Rochelle salt are probably not

reliable because of failure to take into account the effect of the electrical conductivity of the crystals.

ZUR TEMPERATURABHÄNGIGKEIT DER PIEZOELEKTRIZITÄT (The Dependence of Piezoelectricity on Temperature).—A. Perrier. (*Zeitschr. f. Phys.*, 9th Dec., 1929, Vol. 58, No. 11/12, pp. 805–810.)

A paper on the disappearance of the piezoelectric effect on the change from α-quartz to the β form occurring at about 450–550°, and the similar behaviour of other crystals (tourmalin, etc.).

AN INTERFEROMETER METHOD OF OBSERVING THE VIBRATIONS OF AN OSCILLATING QUARTZ PLATE.—H. Osterberg. (*Proc. Nat. Acad. Sci.*, Dec., 1929, Vol. 15, pp. 892–896.)

The writer uses Dye's method of observing and recording the vibrations of piezoelectric quartz by the formation of interference fringes (*see* Nat. Phys. Lab. Reports, 1927, p. 91, and 1928, pp. 113–115 and plates). Among the results obtained, "the crystal is found to respond but feebly at its fundamental. But the surface does not, as frequently supposed, oscillate as a whole."

A PRELIMINARY REPORT ON THE TRUE AND THE APPARENT ELECTRICAL RESISTIVITY OF DIELECTRICS: QUARTZ.—H. Saegusa and K. Saeki. (*Sc. Rep. Tôhoku Univ.*, 1929, Vol. 18, No. 2, pp. 231–244.)

Experimental investigation of the decrease with time of the apparent conductivity of crystalline quartz.

PUSH-PULL PIEZO-ELECTRIC OSCILLATOR CIRCUITS.—J. R. Harrison. (*Proc. Inst. Rad. Eng.*, Jan., 1930, Vol. 18, pp. 95–100.)

Author's summary:—Comparative tests have been made of five different push-pull piezo-electric oscillator circuits. Two of these circuits use three-element tubes: (1) crystal in four-electrode mounting connected to the grids and anodes, (2) crystal in two-electrode mounting connected to the grids. The other circuits use four-element tubes, (3) screen-grid tubes with the crystal in a four-electrode mounting connected to the control grids and anodes, (4) space-charge-grid tubes, quartz crystal in four-electrode mounting connected to the control grids and anodes, (5) space-charge-grid tubes, crystal in two-electrode mounting connected to the control grids. These circuits have been tested at 90 kc. for relative power output and variation of frequency with circuit constants. The type UX-210 tube was used with the circuits (1) and (2) and type UX-865 screen-grid tube with the circuits (3), (4), and (5). The ratios of the power outputs at 90 kc. of the circuits (1), (2), (3), (4), and (5) are 10.7, 9.6, 12.9, 1.68, and 1.0 respectively. The power output of circuit (3) at 315 volts with the grid bias through 2-megohm resistors was 0.50 watt at 90 kc. Using the same circuit with 450 volts on the anodes and the grid bias through chokes, the power output was 5.20 watts. Considering the low frequency these are reasonable values. The power output of the circuits (4) and (5) is abnormally small, but this may be due to the fact that the UX-865 is not particularly well adapted for use in this type of circuit. The circuits have variations of frequency with circuit constants of the same order of magnitude as has been found with the Pierce Oscillator. The circuit of Fig. 3 (push-pull with screen-grid valves, using feed-back through the crystal) is particularly adapted to use with crystals at flexural vibration frequencies.

METHOD AND APPARATUS USED IN TESTING PIEZO OSCILLATORS FOR BROADCASTING STATIONS.—E. L. Hall. (*Bur. of Stds. Journ. of Res.*, Jan., 1930, Vol. 4, pp. 115–130.)

"After preliminary tests to determine the suitability of the quartz plate and its fundamental frequency, the piezo oscillator is kept in a temperature-controlled room for not less than two days, during which frequency measurements are made.

"The method consists in measuring the frequency of the piezo oscillator under test in terms of a 200 kc. temperature-controlled piezo oscillator. This is accomplished by adjusting a radio-frequency generator to the frequency which the piezo oscillator under test should have. This adjustment is made by using harmonics from a 10 kc. generator which is kept accurately set in terms of the 200 kc. standard by observing a special form of beat indicator. The frequency difference between the test piezo oscillator and the generator set in terms of the standard is measured by comparison with an audio-frequency generator. A frequency meter of special design is used to check the frequency difference and determine the sign of the correction to be applied. The method described is also useful in the calibration of frequency meters and the measurement of station frequencies."

THE DIMENSIONS OF LOW-FREQUENCY QUARTZ OSCILLATORS.—R. C. Hitchcock. (*Review of Scient. Instr.*, Jan., 1930, Vol. 1, New Series, pp. 13–21.)

Author's abstract:—The frequencies of the Curie cut quartz oscillator plates from 60 to 320 kc./sec. are shown to be discontinuous functions of the dimensions. The K, "meters per millimeter," is shown to vary from 90 to 145. It is suggested that the use of relative power measurements will insure a single frequency crystal operating at minimum damping.

ESCAPEMENT ERRORS OF PENDULUM CLOCKS.—E. C. Atkinson. (*Proc. Phys. Soc.*, 15th Feb., 1930, Vol. 42, Part 2, pp. 58–70.)

TIME MEASURING BY COMMERCIAL ALTERNATING CURRENT WITH CONTROLLED FREQUENCY.—J. M. Adams. (*Journ. Opt. Soc. Am.*, Dec., 1929, Vol. 19, pp. 384–386.)

A synchronous motor, driven from such a supply, may be depended on for a single measurement of a time interval of the order of 1 sec. with a probable error of $\pm$ 0.0017 sec.

THE CALCULATION OF THE INDUCTANCE OF SINGLE-LAYER COILS AND SPIRALS WOUND WITH WIRE OF LARGE CROSS SECTION.—F. W. Grover. (*Proc. Inst. Rad. Eng.*, Nov., 1929, Vol. 17, pp. 2053–2063.)

"Formulas are given for both wires of round

cross section and wires of rectangular cross section. These are obtained by an extension of the Rosa Method [*cf.* same writer, 1929 Abstracts, pp. 582–583]. Tables are given from which the geometric mean distances of rectangles which enter in the formulas may be readily obtained."

SIMPLE FORMULA FOR THE RAPID CALCULATION, IN ALL CASES, OF OHMIC RESISTANCE FOR A.C.—A. Levasseur. (*Bull. d.l. Soc. Franç.d. Élec.*, Jan., 1930, Vol. 10, pp. 73–81.)

Full treatment of the work referred to in Feb. Abstracts, p. 110.

RASCHET KOEFICIENTOV SAMOINDUKCII PLOSKIH ODNOVITKOVIH KONTUROV (Calculation of the Inductance of Plane Single Turn Loops). —D. A. Vicker. (*T.iT.b.p., Leningrad*, October, 1929, Vol. 10, pp. 470–490.)

In Russian. The loop whose inductance is to be determined, is divided into a number of rectangles whose self and mutual inductances are summed up in accordance with the author's formula for the calculation of the mutual inductance of two rectangular loops lying in the same plane. This summation is facilitated by the use of special tables compiled for different kinds of geometrical figures. The accuracy of the calculation depends on the number of rectangles into which the loop is divided. A numerical example is given.

MEASUREMENT OF HIGH RESISTANCE BY LOSS OF CHARGE METHOD.—S. T. Gaskin. (*Electrician*, 24th Jan., 1930, Vol. 104, pp. 93–95.)

Degree of accuracy: theory, and conditions necessary for accuracy: period of insulation: effect of absorption on result of test.

CONTRIBUTION À LA THÉORIE MATHÉMATIQUE DE LA MESURE DES INDUCTANCES (Contribution to the Mathematical Theory of the Measurement of Inductances).—A. Cabras. (*Rev. Gén. de l'Élec.*, 14th December, 1929, Vol. 26, pp. 959–963.)

Investigates the mathematical theory of the Wheatstone Bridge for the very general case where it is traversed by currents of variable intensity and of any form, and its arms are any complex impedances. The writer's results enable the conditions of balance to be determined for every case, for potentials of any form whatever, even impulsive; they also give information on the maximum sensitivity of the arrangement employed.

THE MEASUREMENT OF RESISTANCE AND REACTANCE AT RADIO-FREQUENCIES.—(*Engineer*, 24th January, 1930, Vol. 149, p. 98.)

A description of one of the N.P.L. exhibits at the Physical and Optical Societies' Exhibition. The method is applicable to measuring the input impedance of valves, the impedance of aerials, etc. It has been used for frequencies up to 10 million p.p.s., and with a few additional precautions could probably be employed with accuracy at still higher frequencies. It is based on the fact that if a circuit consisting of an inductance and a variable capacity, coupled inductively to a self-maintained oscillator, has its capacity increased progressively so that the point of resonance with the oscillator is passed through, the frequency of the latter increases to a maximum value, falls through its original value to a minimum, and then approaches its original value asymptotically.

THE ABSORPTION METHOD OF CAPACITY AND INDUCTANCE MEASUREMENT.—A. P. Castellain. (*E.W. & W.E.*, February, 1930, Vol. 7, pp. 81–84.)

A paper on the use of the anode current change in an oscillator circuit, when resonance is achieved with a coupled oscillatory circuit, for the purposes of capacity and inductance measurement. *Cf.* Tykociner and Armstrong, January Abstracts, pp. 38 and 39.

A VACUUM TUBE IMPEDANCE BRIDGE.—G. A. Stone. (*Journ. Opt. Soc. Am.*, Nov., 1929, Vol. 19, pp. 326–334.)

A study of the Fitch valve potentiometer, derived from Van der Bijl's circuit (*cf.* 1928 Abstracts p. 37), with particular emphasis on its incorporation into a convenient piece of laboratory apparatus. By slightly altering the procedure, the use of the instrument is made easier. Resistances, inductances, capacitances or combinations of these may be measured with an accuracy of at least one half of one per cent.

A QUARTZ SUSPENSION GALVANOMETER FOR USE IN D.C. AND A.C. CIRCUITS.—D. R. Barber. (*Phil. Mag.*, Dec., 1929, Vol. 8, No. 54, pp. 1106–1112.)

For measuring direct or low frequency alternating currents within the range 10^{-3} to 10^{-6}A. Designed for high sensitivity and inherent stability. Two soft iron armatures float within two solenoids: the suspension fibre is anchored at both ends.

THE SENSITIVENESS OF ELECTROMETERS. — E. Perucca. (*Nat. Ac. Lincei*; Summary in *Nature*, 30th Nov., 1929, Vol. 124, p. 862.)

"A conceptual difference in behaviour between quadrant, leaf, and wire electrometers used for the measurement of very small differences of potential by the heterostatic method is pointed out."

ÜBER EINEN NEUEN APPARAT ZUR REGISTRIERUNG DER AUSSCHLÄGE VON EIN- UND ZWEIFADEN ELEKTROMETERN (A New Recording Arrangement for Thread Electrometers).—O. Mathias and V. F. Hess. (*Physik. Zeitschr.*, 15th Aug., 1929, Vol. 30, pp. 508–512.)

An improved micro-photographic method.

NOTES ON THE DESIGN OF 4-TERMINAL RESISTANCE STANDARDS FOR ALTERNATING CURRENT.—F. B. Silsbee. (*Bur. of Stds. Journ. of Res.*, Jan., 1930, Vol. 4, pp. 73–107.)

The theoretical basis is given for the computation of the inductance of resistance standards consisting of a system of straight conductors long in

comparison to their diameters. Formulæ for the skin effect, in various combinations of flat strips and coaxial tubes, are quoted and discussed. Methods of attaching and locating the potential leads, so as to minimise the chance of error from stray magnetic fields and yet to allow convenient adjustment of the resistance, are dealt with. As examples, detailed descriptions of two groups of standards at the Bureau are given.

WIDERSTANDS- UND KAPAZITÄTS-MESSUNGEN DURCH KONDENSATORENTLADUNGEN, MIT EINER ANWENDUNG AUF DIE MESSUNG VON DIELEKTRIZITÄTSKONSTANTE UND LEITFÄHIGKEIT SEHR VERDÜNNTER LÖSUNGEN (Resistance and Capacity Measurements by Condenser Discharges, with an Application to the Measurement of the Dielectric Constant and Conductivity of Very Weak Solutions).—J. Malsch. (*Ann. der Phys.*, 4th Dec., 1929, Series 5, Vol. 3, No. 6, pp. 803–822.)

The method theoretically investigated is that known as the "single-spark" method, in which a condenser is discharged once through an oscillating circuit, and the resultant current measured by the use of a coupled aperiodic "receiving" circuit (Wien: Meisser: Malsch).

ÜBER DIE FORM DER RESONANZKURVEN BEI STEHENDEN ELEKTRISCHEN DRAHTWELLEN (On the Shape of the Resonance Curves of Stationary Electric Waves in Wires).—R. King. (*Ann. der Phys.*, 18th Dec., 1929, Series 5, Vol. 3, No. 7, pp. 934–936.)

Kessenich's paper "On the Effect of an Inductively Coupled Indicator . . ." (Jan. Abstracts p. 51) has led to this preliminary announcement of independent work along similar lines. The "wire" system took the form of tubes, continuously variable from 1 to 14 metres; instead of an inductively coupled indicator, a capacitively coupled one was used, so tuned that for any particular frequency it did not affect the natural period of the system. The oscillator, almost exactly reproducing the parallel wire system on a small scale, could be loosely coupled to it and could be moved freely over the whole length.

By careful adjustment of the indicator coupling and of the length of the system for each selected wavelength, completely symmetrical resonance curves were obtained, as well as a completely symmetrical distribution over the whole system. An important factor in obtaining such symmetry is the position of the oscillator relative to the normal positions of the oscillation antinodes.

ACCURATE WAVEMETER DESIGN.—W. H. F. Griffiths. (*Wireless World*, 29th January, 1930, Vol. 26, p. 113.)

Points in the construction of precision instruments. The author draws attention to the increased necessity for accuracy in view of the crowding on the available etherial waveband. Comparisons are drawn between the percentage accuracy of modern instruments from the standard Multivibrator (0.001 per cent.) and Sullivan-Griffiths Sub-Standard (0.01 per cent.) to the average good portable commercial heterodyne (0.5 per cent.) and the ordinary buzzer type (2.0 per cent.).

MULTI-RANGE METER CONVERSIONS.—W. A. Barclay. (*Wireless World*, 29th January, 1930, Vol. 26, p. 117.)

Showing how, by the application of Ohm's Law, the d.c. moving coil meter can serve a multitude of purposes in the measurement of voltage and current. An abac is reproduced giving the value of shunt or series resistance required in order to change the range of an ammeter or voltmeter.

A METHOD OF INCREASING THE SENSIBILITY OF THE DOLEZALEK TYPE ELECTROMETER: AND A DIRECT READING "NULL" CIRCUIT.—J. M. Pearson. (*Journ. Opt. Soc. Am.*, Dec. 1929, Vol. 19, pp. 371–377.)

An instrument giving normally 800 mm./volt is made to work regularly at 8,000 mm./volt by bending the needle on its axis and tilting the quadrants. The theory is worked out. In the circuit for the direct-reading null method, a resistance is used made by a line of indian ink on soft drawing paper, thoroughly boiled out and sealed in paraffin: it is constant at 2×10^{11} ohms. Currents over a range from 10^{-15} and 0.5×10^{-10} A. can be measured directly.

A THERMIONIC VOLTMETER METHOD FOR THE HARMONIC ANALYSIS OF ELECTRICAL WAVES.—C. G. Suits. (*Proc. Inst. Rad. Eng.*, January, 1930, Vol. 18, pp. 178–192.)

The complex wave is impressed upon the input circuit of a thermionic voltmeter: in series with the source is a local oscillator capable of being tuned to the frequency of the harmonics of the wave under analysis. As this oscillator approaches the frequency of a particular harmonic, the milliammeter needle oscillates at the difference-frequency of the two oscillations; when this difference is made small enough by tuning, the *amplitude* of the beat can be read in milliamperes. From this and from the amplitude of the local oscillation, the harmonic amplitude is obtained by $H = K \cdot \frac{I_b}{L}$ where K is a constant which can be determined. An accuracy greater than 1 per cent. for a harmonic of 10 per cent. of the fundamental, and greater than 3 per cent. for a 1 per cent. harmonic, is obtained.

A PORTABLE PRECISION FREQUENCY METER.—T. D. Parkin. (*Marconi Review*, January, 1930, pp. 1–16.)

A detailed description of this instrument, which covers a range from 10 m. to over 100 m. by the use of four interchangeable inductances. Mycalex is largely used for insulation.

A METHOD OF ELIMINATING MAGNETIC DISTURBANCE OF HIGH SENSITIVITY GALVANOMETERS.—A. B. D. Cassie. (*Journ. Scient. Instr.*, January, 1930, Vol. 7, pp. 21–22.)

"Light reflected from two mirrors oscillating with equal amplitudes and frequency may, by the method described, be projected on a scale to give an image at rest, and this may be employed

to eliminate changes in zero of certain galvanometers."

EIN NETZANSCHLUSS-WELLENMESSER (A Mains-driven Wavemeter).—R. Wigand. (*Rad. B., F.f. Alle*, Feb., 1930, pp. 76–78.)

Description and specification of a mains-driven heterodyne wavemeter.

SUR LE CALCUL D'UN GALVANOMÈTRE (The Calculation of a Galvanometer).— —. Michel. (*Comptes Rendus*, 30th Dec., 1929, Vol. 189, pp. 1257–1259.)

ÜBER DIE MESSUNG SCHWACHER WECHSELSTRÖME MIT HILFE VON TELLUR-PLATIN THERMOELEMENTEN (The Measurement of Small Alternating Currents with the help of Tellurium-Platinum Thermoelements).—H. Teichmann. (*Zeitschr. f. Phys.*, 21st Jan., 1930, Vol. 59, No. 9/10, pp. 615–622.)

The method of construction of the elements is described and illustrated. Various data are given: with 20 elements (for which number the Te-Pt thermo-bridge possesses its maximum sensitivity) the internal resistance is 1,100 ohms and the ratio k (current over square root of resulting thermo-electric potential) = 0.27×10^{-4}. For previous methods the decimal fraction varies from 25.16 (Gerlach) to 1.64 (Austin) and 0.42 (Schering).

A NEW HIGH FREQUENCY AMMETER.—C. L. Fortescue and L. A. Moxon. (*Elec. Review*, 14th Feb., 1930, Vol. 106, p. 294: *E.W. & W.E.*, March, 1930, p. 144.)

Extract from an I.E.E. (Wireless Section) paper describing the construction and theory of the instrument, which is intended for use at any frequency up to 100 million p.p.s. The electrical portion is made in a cylindrical form so that the correction factors for various frequencies may be calculated with certainty. In the model illustrated, each of six parallel wires is kept in its central position on the axis of a screening tube by means of a flat spring at the end. One of the wires is directly attached to what is normally the heated wire of an ordinary hot-wire ammeter. Each of the six wires carries, for a full-scale deflection, about 1.2 A. A symmetrical arrangement of the terminal connections ensures uniform distribution of current between the six.

SHIELDING OF MAGNETIC INSTRUMENTS FROM STEADY STRAY FIELDS.—G. L. Gokhale. (*Journ. Am. I.E.E.*, October, 1929, Vol. 48, pp. 770–774.)

A CONDENSER BRIDGE FOR FACTORY INSPECTION OF VARIABLE CONDENSERS.—R. A. Braden and H. C. Forbes. (*Proc. Inst. Rad. Eng.*, January, 1930, Vol. 18, pp. 123–136.)

Authors' summary:—A capacity bridge designed for routine factory testing of variable air condenser of the "gang" type, as used in modern radio receivers, is described in this paper.

Setting the bridge involves a capacity balance and a phase-angle adjustment. The capacity balance is effected by a balancing condenser which gives directly the capacity difference between two condensers connected to the bridge for test. The phase-angle adjustment is made by rheostats in series with the condensers, and by an arrangement whereby the phase angles of the ratio resistances can be varied slightly for precise adjustment.

Design and construction of some of the more important parts, and testing and calibration of the bridge, are described, and installation and use of the bridge are discussed.

A METHOD OF MEASURING THE OVERALL PERFORMANCE OF RADIO RECEIVERS.—H. A. Thomas. (*E.W. & W.E.*, February, 1930, Vol. 7, pp. 78–80.)

Long abstract of a paper read before the I.E.E. Wireless Section, describing work on the subject carried out at the National Physical Laboratory. The abstract shows, by text and illustrations, the method adopted and the screening precautions taken. The latter portion of the paper discusses suggestions for specifying the performance of receivers: it is suggested that the characteristic of any receiver can be expressed in terms of three characteristics: (*a*) the input voltage, at a definite depth of modulation, necessary to produce a definite standard output at all wavelengths within the desired range; (*b*) the sensitivity variation in the neighbourhood of certain fixed wavelengths—giving the selectivity; and (*c*) the output variation with constant input and depth of modulation, but with variable frequency of modulation—giving the frequency-distorting properties of the audio-frequency stages.

FLIESSFERTIGUNG UND PRÜFUNG VON RUNDFUNKGERÄTEN (The Series-assembling and Testing of Broadcast Apparatus).—(*Telefunken Zeit.*, Sept., 1929, Vol. 10, No. 52, pp. 69–71.)

As an example of modern methods of testing for mass production, the treatment of the screen-grid mains-driven "Telefunken 40" receiver, and its components, is discussed and illustrated.

A METHOD OF SAMPLING INSPECTION: THE FREQUENCY DISTRIBUTION OF THE UNKNOWN MEAN OF A SAMPLED UNIVERSE.—H. F. Dodge and H. G. Romig: E. C. Molina and R. I. Wilkinson. (*Bell Tech. Journ.*, October, 1929, Vol. 8, pp. 613–631 and 632–645.)

(1) "By employing probability theory, the method places a definite barrier in the path of material of defective quality and gives this protection to the consumer with a minimum of inspection expense."

(2) "In drawing conclusions as to the reliability of the mean of a sample it is important that all relevant information be taken into consideration. The mathematical analysis in this paper is based on the Laplacian Bayes Theorem, which implicity comprehends the results of a sample together with the *a priori* knowledge available concerning the parameters of the universe."

A Bridge Grid Resistor Amplifier.—J. Razek and P. J. Mulder. (*Journ. Opt. Soc. Am.*, Dec., 1929, Vol. 19.)

Certain definite advantages over previously proposed instruments are enumerated: it uses ordinary commercial valves, selected only for high internal resistance, it allows these valves to be operated at any points whatever on their characteristics, it makes use of the ionisation currents to obtain high sensitivity, and it allows complete and readily attainable compensation for all battery voltage fluctuations. A time constant of a few thousandths of a second is obtained for the grid circuit. See Feb. Abstracts, p. 110.

Reports of Committees on Electrical Insulating Materials and on Magnetic Properties.—American Society for Testing Materials.

The first report deals with recommendations as to the testing of moulded materials, oils, varnishes, porcelain, cable-splicing, paper, etc. The second deals with tentative definitions of terms, with units and symbols, relating to magnetic testing.

SUBSIDIARY APPARATUS AND MATERIALS.

Contribution à l'Étude du Filtrage des Courants Redressés (Contribution to the Study of the Filtering of Rectified Currents). —M. Demontvignier. (*Bull. d.l. Soc. Franç. d. Élec.*, Sept., 1929, Vol. 9, pp. 982–1019.)

Wave-forms of unfiltered rectified voltages: permissible value of fluctuations—for Wireless transmitters—for receivers—for telephone lines interference: filter elements—condensers—air-core chokes—iron-core chokes—measurements on mean permeabilities—special alloys, "A-Metal" (iron-nickel-copper) of the Ajax Electrothermic Corporation: determination of the optimum induction for a magnetic circuit with iron cores: rapid method of calculation for a series of iron-cored inductances: the various methods of filtering—by pure capacity—by inductance and small impedance —inductance-capacity filters, one stage—multi-stage—resonance filters—filtering by buffer battery.

Plate-Voltage Supply for Naval Vacuum-Tube Transmitters.—E. C. Raguet. (*Proc. Inst. Rad. Eng.*, January, 1930, Vol. 18, pp. 49–66.)

Author's summary:—"This article outlines the Navy's experience and conclusions in regard to the various types of plate supply, for vacuum-tube transmitters, which have been used. After listing and briefly discussing the considerations governing the selection of an ideal plate supply for transmitters, a comparison is made between the various types and the ideal. Navy experience in regard to character and control of output, source of primary power, reliability and repairs, ruggedness and efficiency is discussed in some detail. Data regarding comparative first costs and operating costs are given, followed by a statement of the Navy's present policy in regard to plate supply. In conclusion, the advantages and disadvantages of the motor generator and the mercury-vapor rectifier tube are tabulated."

Hot-Cathode Mercury-Vapor Rectifier Tubes. —H. C. Steiner and H. T. Maser. (*Proc. Inst. Rad. Eng.*, January, 1930, Vol. 18, pp. 67–83.)

Authors' summary:—"High-voltage d.c. power for radio transmitters has usually been obtained from d.c. generators or through rectification of alternating current by means of high-vacuum tube rectifiers or mercury-arc rectifiers. A new type of rectifier tube is described which combines the advantages of the high-vacuum tube with the low and nearly constant arc-drop of the mercury-arc rectifier. Typical tube characteristics and the method of operation are discussed. A method is given for rating rectifier tubes in terms of the fundamental limits of the tube, that is, peak inverse voltage and peak plate current. Single-phase and three-phase circuits are shown for use with the hot-cathode mercury-vapor tube."

The Radiotron is a low-pressure tube (1–30 microns Hg.) and therefore the protecting action of the gas against cathode evaporation and disintegration (by positive ion bombardment) is negligible; the successful working at high voltages is due to Hull's discovery that the disintegration can be avoided completely if the arc-drop is maintained below a critical value (January Abstracts, pp. 43–44). A discussion of this and Raguet's paper (above) is given on pp. 84–87.

A New Rectifying Valve.—E. R. Dietze. (*Wireless World*, 8th January, 1930, Vol. 26, p. 52.)

A description of the Rectron valve, a full-wave rectifier which has attained great popularity in Germany. The valve, which is filled with a mixture of rare gases and mercury vapour at low pressure, has an exceptionally low internal resistance so that the rectified d.c. potential remains practically the same even when the load varies by as much as 100 per cent. The valve has proved specially valuable for battery eliminators.

Untersuchungen über Nutzwirkung, Rentabilität und absolute Güte der Gleichrichter (An Investigation into the Efficiency, Cost of Running and Absolute Merit of Rectifiers).—A. Stier. (*Rad., B., F. f. Alle*, Jan., 1930, pp. 17–20.)

A comparison between electrolytic, vibrating, valve, and copper-oxide types.

Redresseurs à Anode Colloïdale (Colloidal Anode Rectifiers).— —, André. (*Bull. d.l. Soc. Franç. d. Élec.*, Sept., 1929, pp. 961–973.)

History: critical survey of the types already established: methods of supply: applications—for charging filament batteries in Wireless—for motor car batteries, etc.: the possibility of increasing the scope of contact rectifiers, dry and colloidal.

The Mechanism of Electrolytic Rectification. —M. E. MacGregor. (*Nature*, 25th January, 1930, Vol. 125, p. 128.)

In a successful attempt to make available the important electronic valve-action of aluminium and some of its alloys, the mechanism of electrolytic

rectification has been studied microscopically. The conclusion arrived at is that the hypotheses of Burgess and Hambuechen, and of Guntherschulze, concerning the electronic valve-action of electrolytic rectifiers, are both partially correct and that a combination of these two hypotheses is the true explanation. *Cf.* Guntherschulze, 1928 Abstracts, pp. 470, 587.

ANODIC PASSIVITY AND VALVE EFFECT OF ALUMINIUM.—W. J. Müller and K. Konopicky. (*Zeitschr. f. phys. Chem.*, May, 1929, Vol. 141, pp. 343–377: abstract in *Science Abstracts*, Sec. A, 25th Nov., 1929.)

EIN VAKUUM-ENTLADUNGSROHR FÜR SEHR HOHE SPANNUNGEN (A Vacuum Discharge Tube for very high Voltages).—A. Brasch and F. Lange. (*Naturwiss.*, 3rd January, 1930, Vol. 18, p. 16.)

It has hitherto not been possible to maintain potential differences of a higher order than 200,000 volts across the electrodes of a vacuum discharge tube without the occurrence of spontaneous discharge. The present note describes a vacuum tube in which spontaneous discharge is avoided by the elimination of leakages along the inside surface of the tube. Voltages of 1.2×10^6 volts (the amplitude of an oscillating voltage of 50 cycles/sec.) across the electrodes were attained, the value being limited solely by the transformer arrangement available.

VACUUM LEVERS.—H. L. Brose and J. E. Keyston. (*Journ. Scient. Instr.*, January, 1930, Vol. 7, pp. 19–21.)

Flexible corrugated brass tubes are now available which lead to great simplifications in the construction and manipulation of the movable parts of vacuum apparatus.

A BRAUN TUBE [C.-R. OSCILLOGRAPH] FOR DIRECT PHOTOGRAPHIC RECORDING.—M. v. Ardenne. (*E.W. & W.E.*, Feb., 1930, Vol. 7, pp. 66–70.)

An article on the new tube, a German paper on which was dealt with in March Abstracts, p. 169. The fact that even with the comparatively low electron velocities used (giving high voltage-sensitivity) photography of aperiodic phenomena is possible direct from the fluorescent screen is explained by (*a*) the special nature of the latter (a suspension of calcium tungstate in waterglass, spread in an extremely thin film) which gives fluorescence far in the violet part of the spectrum; the minute thickness of the layer, moreover, preventing appreciable absorption; (*b*) the concentration of the ray electrostatically, by the Wehnelt cylinder enclosing the hot cathode—thus the ray passes cleanly through the 2 mm. aperture in the anode, without loss by screening; (*c*) the closeness of the deflecting plates (4–5 mm.) and their relatively long length (10–15 mm.); and (*d*) the presence of a trace of a rare gas, preventing divergence of the ray after passing the anode.

Specimen oscillograms are given, one being a direct record of the modulation of a broadcast transmitter, showing how the amplitude of the r.f. current is, in places, brought right down to zero. "Such an equipment, with a revolving mirror and worked with about 1,000 volts, would be suitable for controlling maximum transmitter modulation."

RESPONSE CURVE RECORDING.—C. L. Fortescue and F. Ralph. (*Elec. Review*, 14th Feb., 1930, Vol. 106, p. 296: *E.W. & W.E.*, March, 1930, p. 146.)

Short summary of an I.E.E. (Wireless Section) paper on the combination of a projection oscillograph with a special amplifier and a variable condenser coupled to the rocking mirror of the galvanometer, by means of which the response curves of electrical circuits can be thrown on a screen or recorded photographically. The horizontal deflection of the spot is made dependent on the frequency change, the vertical deflection on the amplitude of the output of the circuits under test. The capacity in the oscillating circuit consists of two parts, one adjustable by hand, the other continually varied by a driving motor which rotates the moving vanes.

NOTE ON EDDY CURRENT LOSSES IN THE SHEATHS OF RECTIFIER CABLES.—F. W. Carter. (*Proc. Camb. Phil. Soc.*, January, 1930, Vol. 26, Part I, pp. 115–116.)

A calculation of the eddy current losses in the sheaths of cables leading from the supply-transformers to the electrodes of a mercury vapour rectifier; the loss in the sheaths is found to be substantially independent of their nature, when the conductivity of the sheaths is not vanishingly small.

DER FREQUENZGANG DES WIRBELSTROMEINFLUSSES BEI ÜBERTRAGERBLECHEN (The Frequency-Dependence of the Eddy-Current Influence in Transformer and Repeater Iron Cores).—W. Wolman. (*Zeitschr. f. tech. Phys.*, Dec., 1929, Vol. 10, pp. 595–598.)

The increased magnetic resistance at increased frequencies, due to the eddy currents driving the flux from the interior, is unimportant at Power frequencies, all-important at Radio frequencies, and of considerable importance at the intermediate frequencies. The present paper treats the subject quantitatively on lines analogous to the treatment of skin effect (Emde, 1908). An expression is derived for the "Effective Permeability": the value of this is

$$\left|\mu_{eff.}\right| = \mu_0 \cdot \frac{1}{\sqrt{2p_0}} \sqrt{\frac{\mathfrak{Sin}^2 p_0 + \sin^2 p_0}{\mathfrak{Sin}^2 p_0 + \cos^2 p_0}},$$

where μ_0 is the initial permeability without the influence of eddy current effect. The phase-angle of $\mu_{eff.}$ is given by $\tan\left(\phi + \frac{\pi}{4}\right) = \frac{\mathfrak{Sin}\, 2p_0}{\sin 2p_0}$. At low frequencies $\mu_{eff.}$ is equal to μ_0 and remains constant: as the frequency increases it decreases, descending rather suddenly at a critical frequency, which for normal stampings lies in the zone of audibility.

THE AUTOMATIC REGULATION OF TEMPERATURES UP TO 600° C. BY MEANS OF A PLATINUM RESISTANCE REGULATOR.—E. A. Cooke and J. C. Swallow. (*Journ. Scient. Instr.*, September, 1929, Vol. 6, pp. 287–293.)

Control of temperature is accurate to ± 0.1 deg. at 350 deg. C. and ± 0.2 deg. at 600 deg. C.

A THERMOSTAT TO WORK OFF A.C. MAINS.—J. Hume. (*Journ. Opt. Soc. Am.*, Sept., 1929, Vol. 19, pp. 158–161.)

"Little claim is made for originality; rather it is a collection of the best features of various designs which have appeared in the literature from time to time." Among the various points may be mentioned:—instead of the usual bulb, the toluene container is in the form of a zig-zag or spiral tube which, by exposing a large surface, reduces the time-lag. To prevent contact between the grease of the stop-cock and the toluene, a bend filled with mercury is interposed. A thermostat of this design has been working day and night for about five months with a maximum variation of 0.001 deg.

STABILISIERUNG MIT HILFE DER NEON-GLIMMLAMPE (Stabilisation with the Help of the Neon Glow Lamp).—H. Göttinger. (*Rad., B., F. f. Alle*, Nov., 1929, pp. 503–505.)

An article prompted by Pearson's paper in the *Wireless World* (1929 Abstracts, p. 642) on the use of the neon glow lamp for stabilising the connection of an amplifier to a mains unit.

BEAT-FREQUENCY OSCILLATORS.—M. S. Mead. (*Gen. Elec. Review*, Oct., 1929, Vol. 32, pp. 521–529.)

Fields of application—Principles of operation—Requirements—Portable-type oscillators—Laboratory-type oscillators—Design of condenser plates.

A MAGNETICALLY OPERATED MERCURY VAPOUR RELAY.—Gramophone and Marconiphone Cos. (*Engineer*, 17th January, 1930, Vol. 149, p. 74.)

GLOW RELAY.—Isenthal & Co. (*Engineer*, 17th Jan., 1930, Vol. 149, pp. 73–74.)

Operates definitely with an impulse current of 10^{-10} A. and passes 30–40 mA. Re-set by a mechanical relay.

A LIGHTNING ARRESTER FOR RECEIVING AERIALS. (*Rad., B., F. f. Alle*, December, 1929, pp. 573–574.)

Description of the "Protektor II," an outside fixture which combines a spark gap, a carbon discharge gap and a fuse, the last two being enclosed inside porcelain insulators. It is said to make unnecessary any switching to earth of the aerial, and sells at about 4/-.

UNTERSUCHUNGEN ÜBER MONOTELEPHONE (Investigations on Tuned Telephones).—R. Bauder and A. Ebinger. (*E.T.Z.*, 24th Oct., 1929, Vol. 50, p. 1560, summary from *Z. Tech. Phys.*, Vol. 9, p. 65.)

EINE ELEKTROMECHANISCHE "GLEICHUNGSWAAGE" (An Electro-mechanical "Equation Balance").—G. Rosen. (*E.T.Z.*, 28th Nov., 1929, Vol. 50, pp. 1726–1727.)

Equations of high order, with one unknown, can be solved with remarkable accuracy by the use of this balance.

DIELECTRIC ABSORPTION AND DIELECTRIC LOSS.—J. B. Whitehead. (*Journ. Franklin Inst.*, Oct., 1929, Vol. 208, pp. 453–468.)

A report on a series of studies on a condenser of high grade impregnated paper insulation at 60 cycles frequency. The loss as computed from von Schweidler's expressions is compared with the measured values. A close agreement is found between the latter and the values computed on the assumption that dielectric absorption accounts for all the loss; agreement is also found between measured and computed values of the increase in capacity with decreasing frequency, as due to dielectric absorption; *no* indication is found of an initial constant dielectric conductivity, as is proposed by Sinjelnikoff and Walther, and by Tank for liquids.

DIRECTIONS FOR THE STUDY OF MICANITE. (*Journ. I.E.E.*, Oct., 1929, Vol. 67, pp. 1243–1248.)

Report (Ref. D/S 1) of the British Electrical and Allied Industries Research Association.

DIELECTRIC STRUCTURE AND BEHAVIOUR.—J. K. Gillett. (*Electrician*, 11th Oct., 1929, Vol. 103, pp. 423–424.)

"A brief survey of various attempts to define the phenomenon of dielectric failure: the use of porcelain for experimental verification of theory."

THE TESTING OF PORCELAIN INSULATORS.—B. L. Goodlet. (*Journ. I.E.E.*, Oct., 1929, Vol. 67, pp. 1177–1212.)

THE INFLUENCE OF SURFACE CONDITIONS AND SPACE CHARGES ON THE CONDUCTIVITY OF POOR CONDUCTORS.—K. F. Herzfeld. (*Phys. Review*, 1st September, 1929, Vol. 34, pp. 791–807.)

MECHANISM OF DIELECTRIC LOSS AND BREAKDOWN: A RÉSUMÉ OF RECENT RESEARCH.—J. B. Whitehead. (*Elec. World*, 30th November, 1929, Vol. 94, pp. 1083–1085.)

EINIGE ELEKTRISCHE MESSUNGEN BEI HOCHSPANNUNG UND TEMPERATUREN BIS −50 GRAD (Some Electrical Measurements [on Dielectrics] at High Voltages and Temperatures down to − 50 deg.).—R. Vieweg and G. Pfestorf. (*Zeitschr. f. tech. Phys.*, Nov., 1929, Vol. 10, pp. 515–519.)

GLYPTAL MICA MOVES AHEAD—NOW THE FLEXIBLE FORM.—L. E. Barringer. (*Gen. Elec. Review*, Oct., 1929, Vol. 32, pp. 530–531.)

Glyptal resin in a modified form has been found highly advantageous for the production of a flexible form of mica insulation.

INSULATING MATERIALS.—A. R. Dunton. (*Electrician*, 27th Dec., 1929, Vol. 103, pp. 791–792.)

Mention is made of mica lead-borate ("Micalex": *see* 1929 Abstracts, p. 462) and of oxidised aluminium as materials worthy of further development for insulation purposes. The oxide film, when only

half a mil thick, seems capable of withstanding more than 100 v., and has excellent heat conductivity. For insulating busbars, etc., a possible solution is to be found among the new cellulose acetate products, though unfortunately many of these have a rather low softening point. Developments in synthetic resin, paper, and press-board insulating materials (*e.g.*, "elephantide") are mentioned.

STATIONS, DESIGN AND OPERATION.

DIE NEUE GROSS-RUNDFUNKSENDER ROM (Rome's New High Power Broadcasting Station).—(*E.T.Z.*, 9th January, 1930, Vol. 51, p. 64.)

Brief description of this 50 kw. transmitter, made by the Radio Corporation of America. Two transmitting valves, each of 100 kw., are used in the final amplifying stage, the anode supply being 4 A. at 18,000 v. Filaments consume 207 A. at 33 v. Wavelength is 441 m. Modulation is by the Heising circuit. Filament and grid supplies are derived from rotary converters; anode supply from the 45 cycle mains through mercury rectifiers (hot cathode type), three in number, for 600, 3000 and 18,000 v. Height of *T* aerial 78 m.

There is also a Marconi 12 kw. set for 25.4 and 80 m. waves, similar to the Chelmsford short wave transmitter. This is to allow Italians living in America to hear the Rome programmes.

AMERICAN BEAM STATIONS.—M. Ray. (*Wireless World*, 1st January, 1930, Vol. 26, p. 18.)

A description of the beam stations of the Bell Telephone Laboratories of America erected at Lawrenceville (transmitting) and Netcong (receiving). These stations differ from the original Franklin installations in that they were required for telephonic communication with three available wavelengths to ensure reliable service at all times of the day. Details are given of the special aerial reflector system, the quartz oscillator control and the double detection superheterodyne used at the receiving station.

ELECTRICAL ENGINEERING IN 1929.—(*Engineer*, 10th January, 1930, Vol. 149, pp. 37–38.)

Part of a general survey. The Empire Beam services and the four P.O. London—New York telephone channels, the Leafield station and the test channels to Australia and S. Africa, are among the matters touched on.

DAS GEGENWÄRTIGE STAND DER TECHNIK UND DER BETRIEBSORGANISATION DES DEUTSCHEN FLUGFUNKWESENS (The Present Position of Technique and Organisation of German Aircraft Wireless).—F. Eisner and H. Fassbender. (*E.T.Z.*, 30th Jan., 1930, Vol. 51, pp. 157–163.)

First half of the German version of the I.R.E. paper dealt with in March Abstracts, p. 174.

REPORTS OF I.R.E. COMMITTEE ON BROADCASTING. —(*Proc. Inst. Rad. Eng.*, Jan., 1930, Vol. 18, pp. 15–37.)

(1) Requirements of a dummy antenna for use during warming-up period. (2) Location of high-power stations with respect to populous areas. (3) Synchronisation. (4) Permissible deviation of carrier frequency from licensed frequency. (5) Allowable ratio of day to night power. (6) Permissible intensity of harmonics and other spurious radiation. (7) Modulation capability. (9) Effective methods of power rating and radiation measurement. Apparently No. 8 (not received) will deal with fidelity of transmission.

KEEPING WATCH ON TRANSMITTER MODULATION BY C.-R. OSCILLOGRAPH.—v. Ardenne. (*See* end of abstract under "Subsidiary Apparatus.")

GENERAL PHYSICAL ARTICLES.

A NEW RELATIVITY THEORY OF THE UNIFIED PHYSICAL FIELD.—W. Band. (*Nature*, 25th January, 1930, Vol. 125, p. 130.)

A preliminary note of a forthcoming relativity theory of the unified physical field in which the quasi-geometrical interpretation is abandoned and an indeterminate vector field is constructed by means of Eddington's displacement rule, considered as an association rule, and identified at every point with the velocity a material particle might have if present there and then. Maxwell's first set of field laws are found to be identically satisfied and the second set are approximately true for small fields but no longer hold for strong fields in the neighbourhood of atomic nuclei. The introduction of field laws which reduce to Einstein's in the pure gravitational field appears to lead to a principle of selection among the orbits in nuclear regions.

A THEORY OF ELECTRONS AND PROTONS.—P. A. M. Dirac. (*Proc. Roy. Soc.*, January, 1930, Vol. 126 A, pp. 360–365.)

The relativity quantum theory involves one serious difficulty, which is connected with the fact that the wave equation has, in addition to the wanted solutions for which the kinetic energy of the electron is positive, an equal number of unwanted solutions with negative kinetic energy for the electron, which appear to have no physical meaning. The author assumes that all the states of negative energy are occupied, except perhaps a few of small velocity, and consequently, that the holes in the distribution of negative energy electrons are the protons. The ideas are applied to the problem of scattering of radiation by an electron, free or bound, and the old scattering formulas are found to be justifiable.

DIE ÄNDERUNG DER ELEKTRISCHEN LEITFÄHIGKEIT IN STARKEN MAGNETFELDERN (The Variation of Electrical Conductivity in Strong Magnetic Fields).—W. Meissner and H. Scheffers. (*Naturwiss.*, 31st January, 1930, Vol. 18, pp. 110–113.)

A critical comparison of some new measurements and deductions of the authors concerning the influence of magnetic field on electrical resistance of pure metals (chiefly gold) and related questions with the results of P. Kapitza (*cf.* 1929 Abstracts, p. 343) as described by O. v. Auwers (*Naturwiss.*, 1929, Vol. 17, pp. 867–873.)

HIGH FREQUENCY ELECTRIC DISCHARGES IN "NON-CONDUCTING" VACUA.—R. W. Wood. (Summary in *Science*, 13th Dec., 1929, Vol. 70, p. 588.)

Discharges in vacua usually regarded as non-conducting were excited by a c.w. oscillator having a frequency corresponding to a wavelength of 1.75 m. "Very remarkable changes in the gas content of the sealed tube under excitation were observed, the same tube showing a spectrum of pure atomic hydrogen, or pure oxygen, at the will of the operator. Luminous masses of singly ionized molecules of very definite shape (spheres, pointed spindles and pear-shaped bodies) appear in the tube, and their movements under magnetic and electric forces have been studied. These bodies may distribute themselves periodically along the tube, giving an appearance which reminds one strongly of stationary waves." *Cf.* McNeely & Ballou, under "Measurements & Standards."

ILLUMINATED SPACETIME: OPTICAL EFFECTS OF ISOTROPIC RADIATION SPREAD OVER ELLIPTIC SPACE.—L. Silberstein. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 50–57.)

THE MUTUAL ACTION OF A PAIR OF RATIONAL CURRENT ELEMENTS.—G. F. C. Searle. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 92–96.)

DETERMINATION OF THE VARIATION WITH PRESSURE OF THE FORCE BETWEEN TWO PLATES AT DIFFERENT TEMPERATURES AT LOW PRESSURES, WITH A VIEW TO THE DETERMINATION OF MOLECULAR MEAN FREE PATHS.—A. E. Martin. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 97–130.)

THE KIRCHHOFF FORMULA EXTENDED TO A MOVING SURFACE.—W. R. Morgans. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 141–161.)

ON THE TEMPERATURE VARIATION OF THE SPECIFIC HEATS OF HYDROGEN AND NITROGEN.—J. H. Brinkworth. (*Proc. Roy. Soc.*, January, 1930, Vol. 126 A, pp. 204–212.)

THE COLLISION BETWEEN TWO ELECTRONS.—N. F. Mott. (*Proc. Roy. Soc.*, January, 1930, Vol. 126 A, pp. 259–267.)

"The collision between two electrons is considered, making use of the exclusion principle. A scattering law is deduced which differs from that of the classical theory. Some experimental evidence is given in favour of the theory. A scattering law is given for slow α-particles in helium."

THE PRESSURES OF GASEOUS MIXTURES. Part III.—C. C. Tanner and I. Masson. (*Proc. Roy. Soc.*, January, 1930, Vol. 126 A, pp. 268–288.)

An investigation of the compressibilities of mixtures of helium, hydrogen and argon.

AN ATTEMPT TO DETECT AN ELECTRIC MOMENT IN A LIGHT QUANTUM.—R. J. Clark and W. H. Watson. (*Proc. Camb. Phil. Soc.*, January, 1930, Vol. 26, Part I, pp. 117–121.)

The result of this experiment, stated in terms of wave theory, is that the change in refractive index of a vacuum produced by a transverse electrostatic field is less than 1.3×10^{-7} per e.s.u. of electric intensity. *Cf.* corresponding research on the magnetic moment—1929 Abstracts, p. 626.

THE DAMPING PRODUCED BY EDDY CURRENTS INDUCED IN METAL SPHERES AND CYLINDERS OSCILLATING IN A NON-UNIFORM MAGNETIC FIELD, AND ITS APPLICATION TO THE DETERMINATION OF RESISTIVITY.—S. Davies and E. J. Evans. (*Phil. Mag.*, January, 1930, Vol. 9, No. 55, pp. 1–16.)

ON THE EQUATION OF STATE OF AN IONISED GAS.—W. H. McCrea. (*Proc. Camb. Phil. Soc.*, January, 1930, Vol. 26, Part I, pp. 107–114.)

The form of problem considered is to find the pressure in a gas of given temperature in which the numbers of atoms per unit volume at the different possible stages of ionisation are supposed known. The question of the dynamical pressure receives special consideration.

SUR LE DIAMAGNÉTISME DES IONS (The Diamagnetism of Ions).—P. Weiss. (*Comptes Rendus*, 13th Jan., 1930, Vol. 190, pp. 95–98.)

BEMERKUNGEN ZUR IONISIERUNGSWIRKUNG SCHNELLER ELEKTRONEN (Remarks on the Ionising Effect of Fast Electrons).—H. Kulenkampff. (*Physik. Zeitschr.*, 1st Nov., 1929, Vol. 30, pp. 777–780.)

SUR L'ÉMISSION DES RAIES SPECTRALES DANS UN CHAMP ÉLECTRIQUE (The Emission of Spectral Rays in an Electric Field).—E. Sevin: Stark. (*Comptes Rendus*, 3rd February, 1930, Vol. 190, pp. 296–298.)

Stark finds that the intensity of a component deviated towards the red differs from that of the corresponding component deviated towards the violet, and that the sense of this dissymmetry is reversed when the experimenter (viewing longitudinally) reverses his position with regard to the direction of the field. Sevin examines this phenomenon and explains it on his general theory of the nature of Light.

SUR LES MOYENS DE DÉCIDER ENTRE LA NATURE CORPUSCULAIRE ET LA NATURE PUREMENT ONDULATOIRE DE LA LUMIÈRE ET DES RADIATIONS X (On Means of Deciding between the Corpuscular and the purely Undulatory Nature of Light and X-Rays).—E. Sevin. (*Comptes Rendus*, 20th January, 1930, Vol. 190, pp. 175–176.)

A test is proposed in which a beam of electrons is projected in the direction of propagation of a beam of X-rays. The theoretical difference in the result, according to the corpuscular or undulatory nature of the X-rays, is shown.

DIE "KRAFTRÖHRENTHEORIE" DER LICHTQUANTEN UND DIE THERMODYNAMIK DER HOHLRAUMSTRAHLUNG (The "Tubes of Force" Theory of Light Quanta and the Thermodynamics of the Cosmic Rays).—W. Anderson. (*Zeitschr. f. Phys.*, 21st Jan., 1930, Vol. 59, No. 9/10, pp. 700–717.)

THE VARIATION OF THE DIELECTRIC CONSTANTS OF SOME ORGANIC LIQUIDS WITH FREQUENCY IN THE RANGE 1 TO 10^3 KILOCYCLES.—R. W. Lunt and M. A. Govinda Rau. (*Proc. Roy. Soc.*, January, 1930, Vol. 126 A, pp. 213–230.)

THE VARIATION OF DIELECTRIC CONSTANT WITH FREQUENCY.—J. H. L. Johnstone and J. W. Williams. (*Phys. Review*, 1st Dec., 1929, Vol. 34, pp. 1483–1490.)

Measurements of dielectric constants were made of solutions of nitrobenzene and para-dichlorobenzene in mineral oil of high viscosity at three concentrations. Wavelengths were between 34 and 154 m., also 300 m. and 3×10^7 m. A decrease in dielectric constant of nitrobenzene with increasing frequency was found. Para-dichlorobenzene showed no dispersion effect. An approximate value of the relaxation time for nitrobenzene was calculated from the Debye formula after corrections were made for molecular associations. The diameter of the nitrobenzene molecule calculated from it is of the right order of magnitude.

HEAVISIDE'S OPERATIONAL METHOD.—D. P. Dalzell. (*Proc. Phys. Soc.*, 15th Feb., 1930, Vol. 42, Part 2, pp. 75–81.)

The writer shows that it is possible to obtain a complete explanation of Heaviside's method of solving differential equations, by a method incorporating the views of Bromwich with those of Carson. His method, he believes, is identical with that advocated by Van der Pol (March Abstracts, p. 176). It avoids the uncertainties that arise from the use of "operators."

SECONDARY ELECTRON EMISSION FROM A CATHODE IN IONIZED NEON.—W. Uyterhoeven and M. C. Harrington. (Summary in *Science*, 13th Dec., 1929, Vol. 70, p. 586.)

THE BOLTZMANN DISTRIBUTION LAW IN QUANTUM THEORY.—E. H. Hall. (Long Summary in *Science*, 13th Dec., 1929, Vol. 70, pp. 585–586.)

MAGNETRON ULTRA-SHORT WAVES AND THE RATIO E/M.—Kothari and Gogate. (*See* under "Transmission.")

MISCELLANEOUS.

PROGRESS OF WIRELESS COMMUNICATION DURING THE PAST TWO YEARS.—C. E. Kennedy-Purvis. (*Journ. I.E.E.*, December, 1929, Vol. 68, pp. 16–23.)

Chairman's address to the Wireless Section. Among points made are the following:—"Congestion in the ether seems likely to be permanent; congestion will probably always be ahead of technique. As technique improves, additional lines will be started up and will overlap such improvements as may be effected from time to time. It will be foolish to desert the lower frequencies without exploiting them also to the uttermost." The "spark" nuisance is being gradually scotched by the introduction of i.c.w. at all P.O. coastal stations; "it remains for other nations to follow suit." Each British coastal station uses a different note frequency.

Latest developments in Broadcasting, commercial and naval telephony and telegraphy on short waves, research on propagation of short waves, echoes, are all touched on. "Experiments in multiplex transmissions whereby one carrier is made to do duty for one or more channels of telegraphy as well as telephony show signs of promise, but it is rather a question whether the wave-band occupied by such methods at present is not considerably wider than the sum of the wave-bands which would be used by an equal number of separate stations." Regarding "ultra-short" waves, the Marconi Company have obtained results across the Atlantic on a wavelength of 8.67 m.

Very considerable success has attended the use of the water-cooled silica valve; two of these are in regular operation on frequencies of the order of 18,000 kc., handling from 20–30 kw. The silica can withstand very high voltages at frequencies as high as 30,000 kc. "Despite the introduction of the many new and improved [receiving] valves it is fair to say that for frequencies above, say, 8,750 kc. per sec., only slow progress has been made in the development of a system of genuine high-frequency amplification." There is still room for improvement in connection with the reduction of microphonic noises. Also, as frequencies of the order of 30-300 megacycles come into use, valves are needed in which the inter-electrode path is reduced to a minimum.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION. (*Engineer*, 10th and 17th Jan., 1930, Vol. 149.)

Exhibits dealt with include:—Cambridge Recording Colorimeter; Marconi (Langevin-Florisson Chilowsky) sounding device—automatic, direct-reading; Marconi tone generator, 20–10,000 cycles; and a magnetically operated hot-filament mercury vapour relay.

THE PHYSICAL SOCIETY'S EXHIBITION. (*E.W. & W.E.*, Feb., 1930, Vol. 7, pp. 85–87.)

"BEYOND PHYSICS": AN ATTEMPT TO FIND A PERMANENT PHYSICAL BASIS FOR LIFE AND MIND.—O. Lodge. (Review in *Nature*, 2nd November, 1929, Vol. 124, pp. 701–702.)

In this review of a lecture before the Institute of Philosophical Studies, the reviewer remarks that the point of view is so novel and has such implications that it is worthy of careful consideration even should it prove to be untenable. "Sir Oliver pointed out that waves can exist which travel faster than light, but they are mere forms which convey no energy and are therefore unable to affect instruments. The energy is all associated with the groups, which subserve the functions of matter. Experimentally, then, we can deal only with the groups. But what of the component waves which give rise to the groups, which interact with them, which are in fact the very condition for the group's existence? They have no energy of their own, but they achieve results which would not otherwise be achieved. Now life is just such a guiding and directing principle, and the bold hypothesis is advanced that

these constituent waves of excessively high frequency may be the physical basis, though not in the least a material basis, for an idealistic interpretation of the universe in which life and mind are supreme."

A Possible Relation Between Natural (Earth) Radiation and Gene Mutations.—F. B. Hanson and F. Heys. (*Science*, 10th Jan., 1930, Vol. 71, pp. 43–44.)

The writers' tests tend to confirm the results of Babcock and Collins (1929 Abstracts, pp. 589 and 650) in support of Olson and Lewis' suggestion.

Normal Atmospheric Dispersion as the Cause of the "Green Flash" at Sunset, with Illustrative Experiments.—Rayleigh. (*Proc. Roy. Soc.*, January, 1930, Vol. 126 A, pp. 311–318.)

"The ordinary dispersion of the atmosphere near the horizon appears adequate to explain the 'green flash.' It can be imitated experimentally."

Windungsprobe an Spulen mit Hochfrequenz (Tests of Dynamo- and Transformer-Coils by High Frequencies).—J. L. Rylander. (*E.T.Z.*, 14th November, 1929, Vol. 50, p. 1668.)

Summary of an American article on the Westinghouse practice of testing with damped oscillations. Any internal breakdown is indicated by the fall of current in a tuned coupled circuit, consequent on the change of frequency. Frequencies of 10–200 thousand cycles are used for individual coils, 5–100 thousand for complete apparatus.

Die Grosse Deutsche Funkausstellung Berlin 1929 (The Great German Radio Exhibition, Berlin 1929).—H. Kröncke. (*Rad., B., F. f. Alle*, Nov., 1929, pp. 482–491.)

Apparatus described and in some cases illustrated includes, besides receivers, various types of frame aerials: loud-speakers, among them being the AEG electromagnetic type with armature pivot so displaced that the product of magnetic force and leverage remains constant for small and large movements; the "Tangentophon" electrostatic type, requiring no special polarising potential, reasonable in price and apparently very efficient—no design details are given except that the driving force is applied tangentially: valves—a Loewe two-stage multiple valve for a 14–60 m. receiver, with outside metallic electrostatic screening; Telefunken screen-grid valve, also with external screening which, however, is also used to reduce the anode/control grid capacity, the screen being connected to the cathode; and the TKD ultra-short transmitting valve, to Kohl's design, for 14 cm. waves. The G.P.O. short-wave 12-valve receiver (W. Runge), for long-distance reception for re-broadcasting, is described—"more like a piece of machinery than a receiver"; no l.f. amplification is needed, the rectifier output being at about 20 v.

Physikalische Grundsätze für die Unterdrückung von hochfrequenten Störungen (Physical Principles for the Suppression of H.F. Interference).—F. Conrad. (*Zeitschr. f. tech. Phys.*, November, 1929, Vol. 10, pp. 508–511.)

A paper on the treatment of various electrical apparatus to prevent or reduce their disturbing effect on radio reception: the chief lines of action are the reduction of sparking; the diminution of the oscillating and radiating properties by earthing, by decreasing the natural frequency and increasing the effective resistance; and in certain cases the use of an earthed Faraday cage. In the special case of a purely electrical coupling with the receiver circuits, a capacitively-symmetrical design of the electrical apparatus is effective.

An Intense Source of Continuous Ultraviolet Light.—E. O. Lawrence and N. E. Edlefsen. (*Review of Scient. Instr.*, Jan., 1930, Vol. 1, N.S., pp. 45–48.)

A water-cooled hydrogen discharge tube of great current-carrying capacity is described, which the writers believe to provide a source many times more intense than any similar sources used hitherto.

Wireless in Train Shunting. (*Engineer*, 24th January, 1930, Vol. 149, p. 102.)

The L.N.E. Rly. has recently conducted experiments in the use of Wireless for handling goods trains in shunting yards, the object being to provide communication between the driver and the control tower. *Cf.* Steinner, 1928 Abstracts, p. 408.

Durium: A Synthetic Resin for Cheap and Almost Indestructible Phonograph Records.—H. T. Beans. (*Science*, 17th Jan., 1930, Vol. 71, pp. x–xii.)

The Problem of Distortion in Sound [Talking] Film Reproduction.—C. O. Browne. (*See* under "Acoustics.")

The Analysis and Measurement of the Noise Emitted by Machinery.—Churcher and King. (*See* under "Acoustics.")

La Localisation des Pailles dans les Arbres des Machines (The Localisation of Flaws in Machine Axles).—J. Peltier. (*Comptes Rendus*, 18th Nov., 1929, Vol. 189, pp. 845–846.)

Further development of the work referred to in 1929 Abstracts, p. 347.

The Use of Piezoelectric Quartz on a Test Bench for the Balancing of Rotors.—P. Langevin. (French Patent: long summary in *Rev. Gén. de l'Élec.*, 28th Sept., 1929, Vol. 26, pp. 114D–115D.)

Some Recent Patents.

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each.

AUTOMATIC VOLUME CONTROL.

Convention date (U.S.A.), 7th July, 1927. No. 293462.

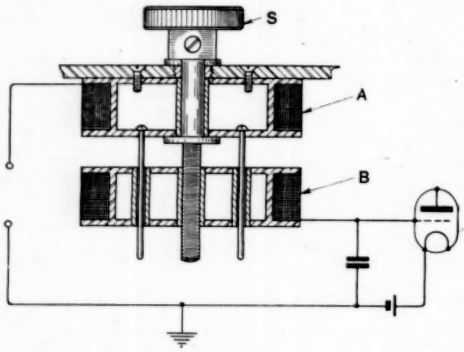
The limit of amplification, in a multivalve set, is automatically maintained constant by causing the rectified current flowing in the output circuit of the detector valve to create corresponding voltages across a resistance connected between the plate and filament of that valve. The fluctuating potentials so derived are fed back to the grid of the first high-frequency stage so as to vary its amplification factor in a reverse sense to the value of the output from the detector.

Patent issued to Hazeltine Corporation.

SCRATCH ELIMINATORS.

Application date, 19th July, 1928. No 320662.

To eliminate scratch from an electric pick-up two variably coupled coils *A*, *B* are inserted in series in the input circuit as shown. Each coil



No. 320662.

preferably consists of 5,000 turns of 32 d.s.c. wire wound on a 1¾in. spool. The degree of coupling is adjusted by a micrometer screw.

Patent issued to G. D. Powell.

Application date, 29th August, 1928. No. 320723.

In this case surface scratch is excluded from the loud-speaker by shunting across the input circuit a sensitive device, such as the known type of marginal relay used in telephony. During the starting period, when surface noises are most prominent, the impedance of the relay to such currents is so low that it acts as an effective short-circuit across the input. During normal operation the impedance is so high that it does not shunt away any appreciable amount of the pick-up energy.

Patent issued to W. E. Beatty.

GAS-DISCHARGE RECTIFIERS.

Application date, 25th May, 1928. No. 320031.

A gas-filled rectifier, without an independently heated cathode, and operating by an independent glow discharge, is characterised by the feature that the anode is surrounded by a conducting shield not wholly enclosing the anode, and insulated from both the anode and cathode. This suppresses arcing and parasitic discharges without materially increasing the glow potential of the device. The distance between the anode and the protecting shield is much greater than the mean free path of the electrons present in the gaseous medium.

Patent issued to the M.-O. Valve Co., Ltd.

INDIRECTLY HEATED VALVES.

Convention date (Germany), 6th December, 1927. No. 301827.

In order to prevent the fluctuating magnetic field (due to the A.C. current applied to the heating-unit) from influencing the operation of the valve, the heating-element is enclosed within a conducting shield or screen, and is connected to it at one end, so that the screen forms part of the heating circuit. The screen thus generates a magnetic field in opposition to that created by the current flow in the heater, which is thereby neutralised.

Patent issued to Telefunken Ges.

VALVE-HOLDERS.

Application date, 21st August, 1928. No. 320460.

A contact plug socket consists of two approximately parallel legs connected at their upper ends so as to form an inverted U. The upper band is pierced with a hole to take one of the valve-holder pins, which is then gripped between the springy parallel legs. Four or more such sockets are mounted on a casing fitted with registering holes to take the standard four- or five-pin valve base.

Patent issued to A. H. Whiteley.

ELIMINATING FADING EFFECTS.

Convention date (U.S.A.), 20th February, 1928. No. 306460.

In order to overcome strength fluctuations due to fading, the incoming signals are received separately on two aerials, spaced apart, but connected to a common receiver, so that if fading occurs at one point signal strength is maintained from the second aerial. According to the invention, the aerial which, at any given moment, is yielding adequate signal strength is caused automatically to reduce the sensitivity of the chain of amplifiers connected to the other aerial, so as to cut out any atmospherics or similar undesired "noise" emanating from the latter.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

TELEVISION SYSTEMS.

Application dates, 16th April and 24th May, 1928. No. 320627.

The invention claims, in combination with the object to be televised and the necessary light-sensitive cells, a number of reflecting surfaces arranged to the side of or around the object, for the purpose of concentrating on to the cells any light scattered laterally from the object.

Application date, 16th April, 1928. No. 320628.

In order to synchronise a television transmitter or receiver a centrifugally-governed driving motor is switch-controlled, the governor device being provided with a loading spring so as to render it substantially unstable. An additional light spring is brought into operation by the switch when the motor reaches the correct running speed.

Application date, 20th June, 1928. No. 320687.

Covers the combination of an electric gramophone amplifier, a wireless receiver, and a television receiver so arranged that the last-named can be operated at choice by either of the first two devices.

Application dates, 16th April, 25th April, 14th May and 26th May, 1928. No. 320639.

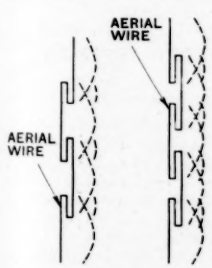
Relates to synchronising arrangements in which a timing signal is used, and in which the receiver is coupled by a synchronising-switch to a correcting-device in such a way that when the receiver is out of phase the timing-signal operates the correcting device, but otherwise not. The invention consists in introducing the timing-signals into the transmission line of the modulated current derived from the light-sensitive cell. Or the timing signal may be produced by interrupting this modulated current.

Patents issued to J. L. Baird and Television, Ltd.

DIRECTIONAL AERIALS.

Application date, 17th July, 1928. No. 320245.

An aerial, long relative to the wavelength employed, consists of a continuous wire which is reversed in direction at alternate half wavelengths, the object being to secure a highly-directional effect without any substantial suppression of radiation. The direction of current in the reversed portions is such that the radiation from these portions is added to that from the other aligned portions. Two such arrangements are shown in the Figure. An increase in the number of wavelengths of wire, for a given linear extension of wire, results in an increased radiation per unit length over the whole aerial.



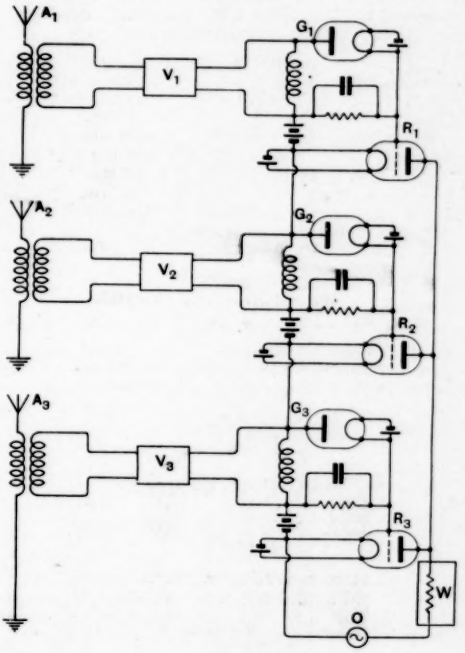
No. 320425.

Patent issued to C. S. Franklin and E. Green.

PREVENTING FADING.

Convention date (Germany), 13th February, 1928. No. 305987.

The signal pick-up from each of three widely-spaced aerials A_1, A_2, A_3 is fed through amplifiers V_1, V_2, V_3, to rectifiers G_1, G_2, G_3 placed across the



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input circuits of three valves R_1, R_2, R_3. The latter are shunted across a common circuit fed by a 5,000 cycle alternator O in series with a high resistance W. If the resistance W is high compared with the internal resistance of the valves R, the current strength in the A.C. circuit of the alternator will be practically the same, whether one or all of the valves are rendered conducting by the rectified voltages from the aerials, thus giving a constant overall strength of signal.

Patent issued to Telefunken Ges.

GRAMOPHONE PICK-UPS.

Application date, 10th August, 1928. No. 320981.

Relates to pick-ups of the kind in which a movable part carrying the gramophone needle oscillates between the pole-pieces of a magnet. According to the invention, the movable part consists of bars of Swedish iron carrying the windings and forming the magnet. This permits of a compact construction, the whole device measuring not more than 1in. by $\frac{3}{4}$in. by $\frac{1}{2}$in.

Patent issued to S. G. Brown.

BAND RECEIVERS.

Convention date (U.S.), 1st August, 1927. No. 294939.

In order to impart a flat-topped characteristic to a wireless receiver, corresponding to the carrier-wave and sideband frequencies, with a sharp cut-off on each side, a filter circuit is interposed between the aerial and the input to a multistage H.F. amplifier. The filter circuit comprises two series-tuned branches with a central shunt of low reactance. The width of the band passed by such a circuit, expressed as a fraction of the carrier frequency, is equal to the ratio of the shunt reactance to the "balanced" reactances of the two series-tuned branches. The condensers of the band filter are ganged with the ordinary tuning condensers, and the tuning of each successive stage of valve amplification is graded so as to cover the whole band admitted by the filter.

Patent issued to Vreeland Corporation.

BEAM AERIALS.

Application date, 26th September, 1928. No. 321025.

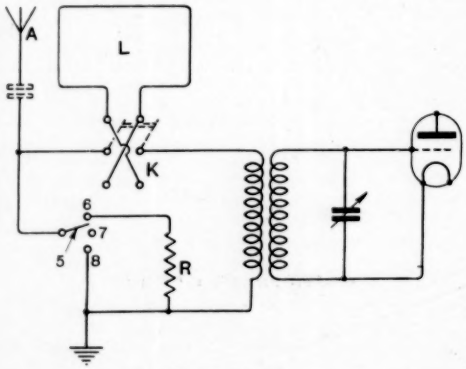
The direction of radiation from a beam aerial is varied or "warped" by feeding the antenna system in such a way that the amplitude of the oscillations along the line of radiator elements gradually increases or decreases from one side to the other, whilst the phase of the currents is maintained constant.

Patent issued to S. G. S. Dicker.

DIRECTION-FINDING EQUIPMENT.

Application date, 22nd November, 1928. No. 322326.

The effect of a vertical aerial *A* is alternately added to and subtracted from the effect of a loop aerial *L*. The latter is rotated to such a position that no change in signal strength indicates that



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the loop is in the "minimum" position, although at the same time a strong signal is being received instead of a zero signal. When the switch 5 is on contact 6 a "phasing resistance" *R* is inserted in series with the aerial *A* for combined working; on contact 7 the aerial *A* can be used alone; whilst on contact 8 the aerial *L* is effective. When the switch 5 is in the first position, a reversing switch *K* allows the effect of both aerials to be alternately added and subtracted, in order to ascertain the required critical setting of the loop *L*.

Patent issued to R. T. and C. H. Smith.

TELEVISION SYSTEMS.

Application date, 6th June, 1928. No. 322481.

Instead of making the light apertures in the exploring disc of symmetrical, *i.e.*, circular or square form, they are made oblong, the dimension of each aperture along the direction of exploration being different from that at right-angles thereto. This is stated to increase the amount of light falling upon the sensitive cell, and to eliminate any tendency to accentuate the light and shade contrasts.

Patent issued to J. L. Baird and Television Ltd.

Application date, 9th July, 1928. No. 322504.

The transmitter comprises an induction coil surrounding a tube containing nickel tetracarbonyl through which a beam of light is projected from the object being televised. The beam passes through an optical objective to form a miniature image, which is rapidly interrupted by a rotary shutter. The receiver comprises a similar induction coil, carrying the received currents, and influencing a doubly refracting medium arranged between two plane polarisers, which intercept the rays passing from a light source to the viewing-screen.

Patent issued to F. H. Rogers.

Application date, 11th July, 1928. No. 322823.

A receiver for reproducing television effects in natural colour is characterised by the use of three separate types of glow-discharge tubes: one containing helium to give a blue light; another containing mercury vapour to give a green colour; and a neon tube for red light. A supply voltage of from 400 to 800 volts is used, giving a current through the lamps of from 20 to 40 milliamps. The luminosity is from 0.1 to 0.35 candle-power per square cm.

Patent issued to J. L. Baird and Television Ltd.

SYNCHRONISING IN TELEVISION.

Convention date (U.S.A.), 23rd June, 1927. No. 292597.

Two or more waves of different frequency are transmitted simultaneously with the picture signals. The lower frequency co-operates with a current of slightly different frequency generated at the receiving end, and the local motor is coarsely synchronised by the phase-difference between the two. Once this stage has been reached, the receiving motor is accurately synchronised and maintained in step by the second or high-frequency timing wave alone.

Patent issued to Electrical Research Products Inc.

UTILISING "COSMIC" RAYS.

Application date, 31*st July*, 1928. *No.* 322485.

It is stated that ultra high-frequency radiation, such as the "cosmic" rays investigated by Professor Millikan, has a beneficial effect upon human and other animal and vegetable life. The inventor proposes to collect this form of radiant energy upon small open metallic circuits, such as split rings, incorporated into a belt or garment, which is wrapped around the organism to be treated.

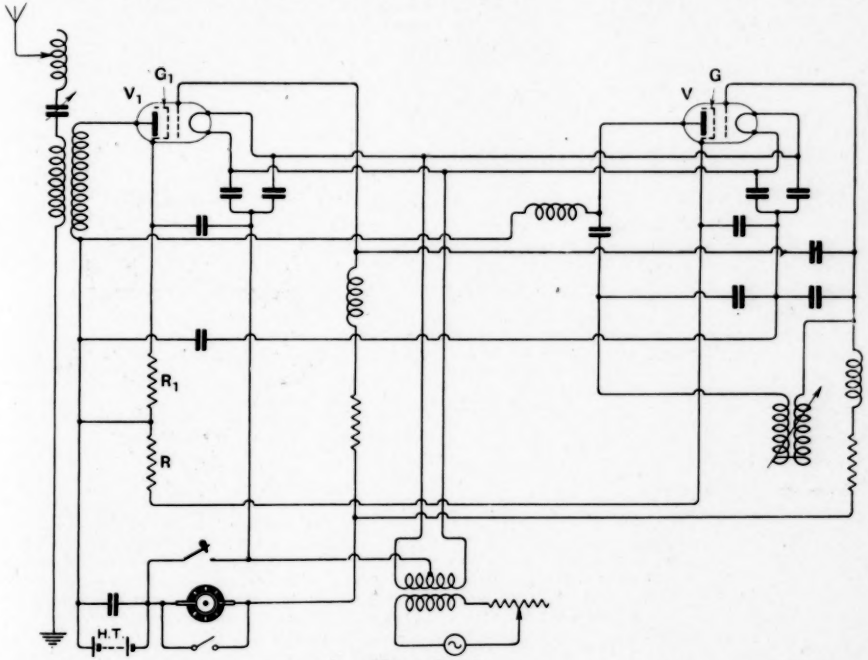
Patent issued to G. Lakhovsky.

STABILISED OSCILLATION GENERATORS.

Convention date (*U.S.A.*), 27*th March*, 1928. *No.* 308716.

The oscillation generator V and power amplifier V_1 are both provided with an additional screening-electrode G, G_1 interposed between the ordinary grid and the anode. The screening-electrodes are connected through resistances R, R_1 respectively to the high-tension source HT, the drop across the resistances being such as to reduce the full HT voltage by one-third or one-quarter. The object of the arrangement is to reduce or eliminate the effect of any impedance-variation occurring in the aerial or output circuits upon the frequency of the generated oscillations. Should any such external variation take place, a correspondihg change will tend to occur in the AC resistance of the tube. This in turn alters the current flowing through the resistances R, R_1, thereby increasing or diminishing the biasing-voltage applied to the screening electrodes G, G_1 in such manner as to compensate automatically for the disturbing factor. In this way the oscillation frequency is held steady.

Patent issued to The British Thomson-Houston Co., Ltd.



No. 308,716.

AMPLIFYING CIRCUITS.

Application date, 24*th October*, 1928. *No.* 322294.

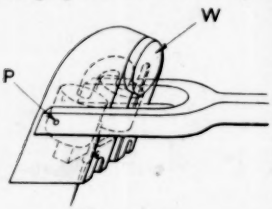
Relates to amplifying systems in which a direct or slowly fluctuating voltage is amplified by being superposed on a high-frequency wave, and consists of an arrangement designed to permit a greater overall efficiency. The low-frequency input is applied between the grids of two valves arranged in push-pull, the valves being fed simultaneously from a high-frequency source. The high-frequency currents are balanced in the output circuit so long as there is no low-frequency input, but when the latter is applied the amplitude of the output varies accordingly. By suppressing the high-frequency output, a higher amplification of the applied low frequency can be secured without danger of overloading the valves.

Patent issued to S. G. S. Dicker.

GRAMOPHONE PICK-UPS.

Convention date (*France*), *10th May*, 1928. *No.* 314759.

The pick-up is pivoted at *P* on a horizontally swinging arm in such a way that the pivotal axis passes through the body of the pick-up so as to impart substantial equilibrium about this axis, and at the same time reducing wear on the record. A counterweight *W* serves to balance the casing, whilst allowing sufficient pressure of the needle on the surface of the record.



No. 314759.

Patent issued to J. Dieux.

Application date, *14th September*, 1928. *No.* 322813.

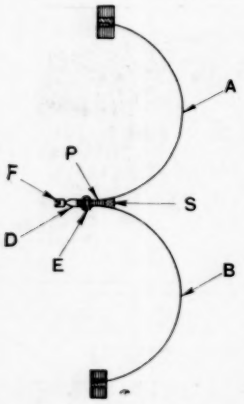
The magnet is fitted with co-operating polepieces so shaped as to provide an annular space or air-gap of rectangular, square, or circular form, inside which is located a moving coil driven by the stylus bar. The magnet is formed as a closed ring, with a central polepiece to provide the necessary air gap.

Patent issued to C. Berrage-Moulton.

LOUD SPEAKERS.

Convention date (*Holland*), *9th February*, 1928. No. 305669.

Two semi-cylindrical sheets *A*, *B* of elastic material, such as press-spahn, are arranged side by side, the adjacent edges being secured to a bridge-piece *P* to which the driving-rod is connected by a bolt *E* and clamp *F*. A strip of resilient material *S*, such as felt is laid over the bridge-piece as shown. The outer edges of the diaphragm are clamped to a wooden frame. The bridge-piece *P* is approximately triangular in section, the greatest depth lying in the plane of the driving-rod.



No. 305669.

Patent issued to H. W. F. X. Beckers.

Application date, *29th August*, 1928. *No.* 322470.

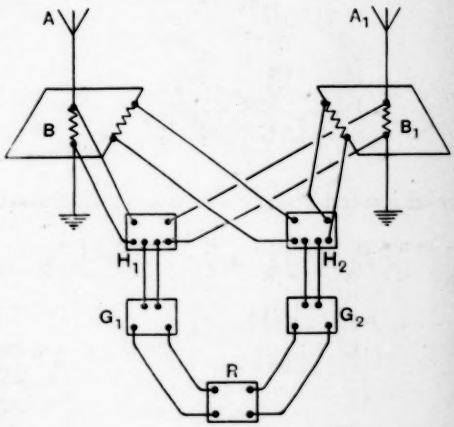
In order to increase the radiation resistance of the diaphragm for the lower frequencies, the speaker as a whole is so located in the corner of a room that the solid angle formed by the converging side-walls and floor is completely closed in or isolated, the surfaces thereby constituting an effective horn of large dimensions. In addition to augmenting the lower musical frequencies, the whole volume of sound is raised, whilst the improved damping so obtained masks any transient distortion effects.

Patents issued to Standard Telephones and Cables, Ltd., and E. K. Sandeman.

MINIMISING FADING.

Convention date (*Germany*), *24th February*, 1928. *No.* 306538.

Fading is analysed as being due to two principal causes: first, interference between the earth-bound and space components of the signal radiation; and secondly, variations in the polarisation of the incoming wave. The first cause is eliminated by receiving the signals on a number of spaced aerials, and the second by using for each aerial system a combination of a vertical wire *A* and a horizontal loop *B*. As shown in the figure, signals received upon the two vertical aerials *A*, A_1 are combined in a common circuit H_1, whilst those received on the loops *B*, B_1 are fed to a common circuit H_2. These in turn supply rectifiers, G_1, G_2, the low-frequency outputs being finally combined in a common indicator or receiver *R*.



No. 306538.

Patent issued to Telefunken Ges für drahtlose Telegraphie.